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Fifty Years of Postwar Science and Technology in Japan

Edited by
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Foreword

This August marks 50 years since the end of World War II. Japan emerged from the ruins to overcome the post-war devastation to achieve a high level of economic growth and become the second largest economy in the world. Science and technology have played major roles as a driving force behind this quest for prosperity. However, it seems as though true prosperity is not necessarily being enjoyed by citizens of Japan today.

Japan is becoming an aging society. To realize a truly rich and prosperous society in which people can live comfortably, it is important to further raise the level of science and technology. It is also necessary to ensure this development by revitalizing the economy, and to continue to utilize science and technology as an endless resource to create assets for society as a whole which will be inherited by future generations.

With this viewpoint in mind, this White Paper looks back on Japan's scientific and technological development over the last 50 years, and considers the future of science and technology with a view toward realizing the true prosperity for its people. It is our hope that this White Paper will be helpful for considering the scientific and technological activities needed to bring about a Japan whose people are truly prosperous, and we will, as a government, continually increase our efforts toward the promotion of science and technology.

In closing, I would like to encourage the citizens of Japan for their continued understanding and cooperation.

July, 1995

Makiko Tanaka
Minister of State for Science and Technology

Preface

After surviving the devastation of war, Japan overcame the chaos of the early postwar years to initiate high-level economic growth and eventually achieve her current status as the world's second-largest economy. Japan's current affluence is the product of the Japanese people's long years of diligent efforts in pursuit of prosperity. During this fifty-year period, science and technology have also played a major role as the driving force behind this quest for prosperity. In addition to constantly influencing society and the economy, they have also changed in response to the country's socioeconomic needs themselves.

As Japan approaches the 50th anniversary of the War's end, the Cold War that so extensively shaped the postwar era has come to an end, and the world now finds itself in the midst of monumental change. Japan also faces issues such as how to respond to the aging of society, as well as environmental and other issues global in scale. At the same time, Japanese economy that has made her affluent lifestyles possible is now beset with formidable circumstances.

In a period like the current one, it should be meaningful, in terms of assuring further development in Japan's future, to reexamine postwar Japan's progress in, and approach to, science and technology as the nation adapted to the exigencies of each period, and to attempt an analysis that seeks to determine the appropriate perspective from which to undertake future endeavors in science and technology.

In keeping with this viewpoint, Part 1 of this White Paper analyzes scientific and technological activity in postwar Japan over the past 50 years and the changes made in the nation's basic approach to science and technology, the objective being to provide basic information to the public for expanding discussion on promoting science and technology from now on.

Part 2 consists of comparisons with other nations in the areas of science and technology, and an overview of related activity in Japan today. Part 3 summarizes the specific science and technology policies being promoted under the General Guidelines for Science and Technology Policy, the foundation of Japan's science and technology policy.

Part 1
Fifty Years of Postwar Science and Technology in Japan

1.1 Indicators that Explain Fifty Years of Postwar Scientific and Technological Activity in Japan

The environment for scientific and technological activity in Japan immediately following the end of the Second World War is described by the Industry and Technology Agency in its Technology White Paper of 1949 in the following way: "The usual tendency to underestimate Japan is further aggravated because we are not capable of providing actual examples of gaining wealth through the incorporation of the fruits of testing and research. The reality is that due to losing the war, a balanced government, public and private budgets are close at hand. Testing and research, having long-term characteristics, often tend to be put off until later. Currently, testing and research institute activities in Japan in general are in a slump."

Although Japan's scientific and technological activity was severely depressed in the early postwar years, recovery was gradual but unfaltering. After following a policy of introducing foreign technology, a heightened awareness of the need to develop original technology promoted a transition to a framework wherein Japan would create new technologies through her own R&D efforts. This in turn led to increasing research and development expenditures, larger and larger numbers of persons involved in research, and generally revitalized research activity. The results of this were larger numbers of academic papers released, more patent applications, and greater technology exports.

Furthermore, the ratio of investment in research and development to GNP has continued to rise until recently, making science and technology an increasingly important part of activities of the society including economic activity.

Chapter 1 uses various statistical indicators to review Japanese scientific and technological activity of the past 50 years and the circumstances surrounding this activity.[1]

1.1.1 Research Expenditure

Research expenditures can be used as an indicator of a society's input as regards research activities. This section will take a general survey of the conditions for scientific and technological activities in society by an examination of the research expenditures.

1.1.1.1 Total Research Expenditures

According to the Report on the Survey of Research and Development (Survey started in 1953 under the name, Statistical Survey of Re-

---

1)In this paper, "research activities" apply only to natural sciences and not to humanities and social sciences. Cases which involve humanities or social sciences will be annotated. Classification of natural sciences as distinct from social sciences and humanities is based on the individual research institute or university and college class departments concerned.

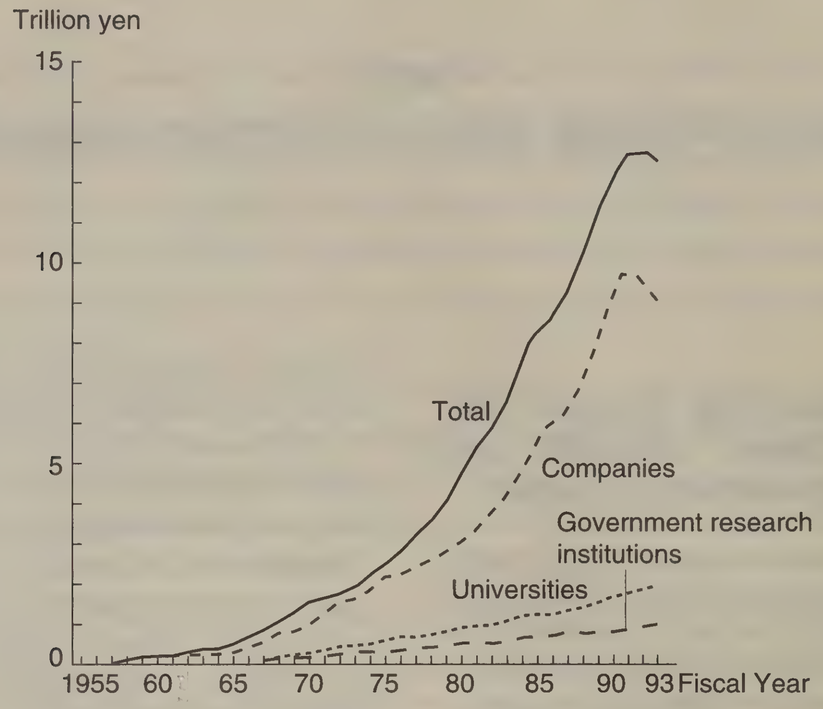

Figure 1-1-1(1) Changes in total research expenditures

Note: "Government research institutions" are defined as national research institutes, public research institutes, and special public research corporations.

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

search Institutions. From 1960, surveys of companies were carried out on a corporate level rather than an institution level, and the survey method has remained largely the same up to the present) by the Statistics Bureau of the Management and Coordination Agency, Japan's research expenditures have been rising at a consistently high rate since this survey was first taken in the 1950s (Fig. 1-1-1 (1)). The 1960 figure of 184.4 billion yen rose to 1,195.3 billion by 1970 (6.5 times the 1960 amount), to 4,683.8 billion by 1980 (a 25.4-fold increase over 1960), and by 12,089.6 billion in 1990 (a 65.6-fold increase). Thus, through the 1980s Japan's research expenditures continued to grow by a significant rate each year. With the 1990s, however, came a prolonged recession following the collapse of the bubble economy, along with a rapidly appreciating yen and other unfavorable factors. Private-sector research investment fell two consecutive years in 1992 and 1993, resulting, in 1993, in the first decrease in nation's total research expenditures since this survey began.

Research expenditures by corporations, universities, and government research institutes (national research institutes, public research institutes and special public research corporations), which are the main ones carrying out research activities, grew steadily without much change until FY1980, with the amount of expenditure in FY1980 ranging between 22.9 and 26.9 times that of FY1960 (Fig. 1-1-1 (2)). In the 1980s, corporations showed high rates of

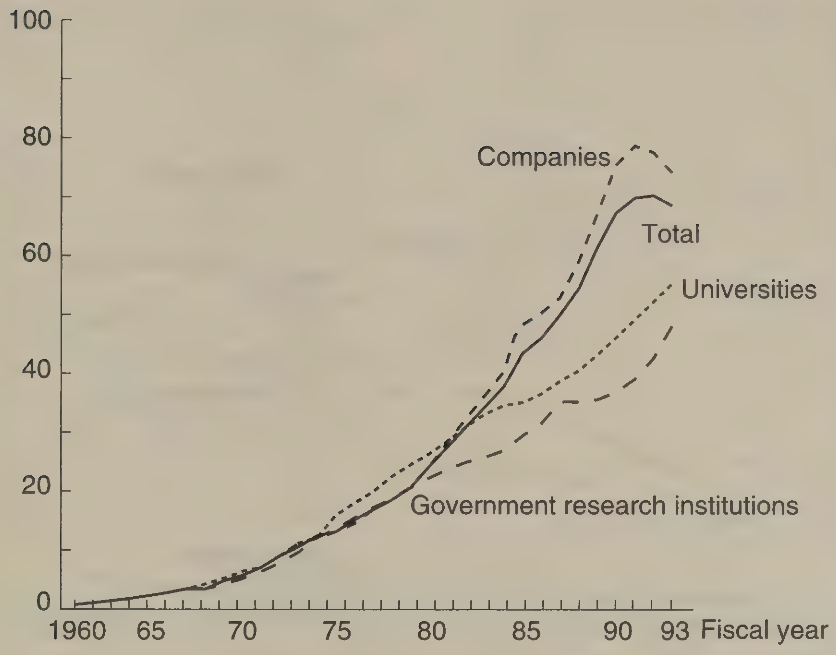

Figure 1-1-1(2) Increases in research expenditures among organizations

Note: This figure shows the transitions of relative value taking the research expenditures of each organization in FY1960 as 1.

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency

growth, achieving in FY1990 a total expenditure 74.5 times that of FY1960. However, lesser growth was recorded by universities and government research institutes, which recorded expenditures of 45.9 times and 36.2 times higher than that of FY1960, respectively. In the 1990s, although corporate research expenditures are on the decline, expenditures by universities and government research institutes have significantly increased.

1.1.1.2 Research Expenditures as a Percentage of GNP

Between 1960 and 1970, research expenditures increased greatly as a percentage of GNP —from 1.11% to 1.59% (Fig. 1-1-2). After leveling off between the two oil crises (in 1973 and 1979), this percentage began growing again in the late 1970s, and between 1980 and 1990 rose from 1.91% to 2.78%. In the 1990s, however, stagnating research investment caused research expenditures to drop as a percentage of GNP—to 2.66% by 1993.

Assessing this ratio of research expenditures to GNP using indicators of scientific and technological efforts as a part of total economic activity, it can be said that Japan's research activity is an increasingly larger part of the nation's economy.

Looking at research expenditures as a percentage of GNP in each sector, the private sector's share has been rising steadily, from 0.83% in 1960 to 1.19% in 1970, 1.41% in 1980 and 2.32% in 1990. This share rose at a particularly rapid rate in the 1980s, pulling up total national

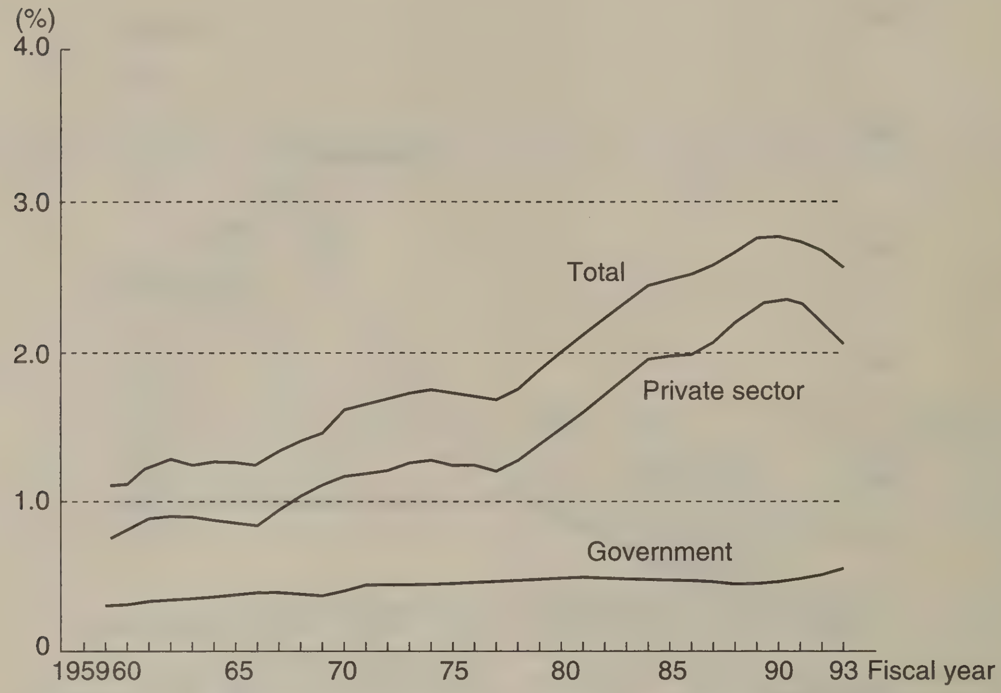

Figure 1-1-2 Changes in research expenditures as a percentage of GNP in each sector

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

research expenditures as a percentage of GNP as a result.

In contrast, the government's share of research expenditures as a percentage of GNP has not changed significantly, registering 0.28% in 1960, 0.40% in 1970, 0.49% in 1980, and 0.46% in 1990. Generally, it may be said that the government increased its research investment in response to economic growth.

1.1.1.3 International Comparison of R&D Expenditures as a Percentage of Gross National Product (GNP)

A comparison of R&D expenditures as a percentage of gross national product among the major countries reveals an increase in R&D investments by Japan (For comparison, statistics for all countries include research in social sciences and humanities) (Fig. 1-1-3).

While Japan lagged behind major countries in the 1960s, its 1.80%, though low as an advanced country, cut the difference with France, which stood at 1.88%. In the 1970s, Japan's percentage continued to grow while other countries were on the decline. In FY1972, Japan surpassed France, in FY1983 the United Kingdom, in FY1987 the U.S., and finally, in FY1989 it passed Germany to achieve the highest standard in the world. Subsequently, Japan's percentage has fallen to 2.91%, due to a decrease in private investments in R&D.

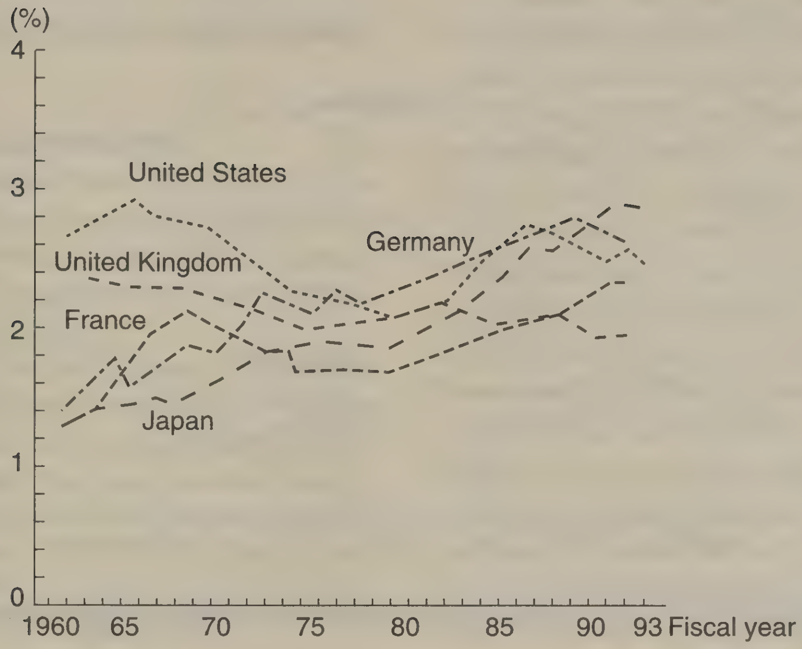

Figure 1-1-3 Comparison of R&D expenditures as a percentage of GNP in selected countries.

Notes: 1. Statistics for all countries include research in social science and humanities.
2. Years for which data are not available are indicated using a straight line.

Sources: Japan: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
United States: "Science and Engineering Indicators 1993" by the National Science Board.
Germany: "Bundesbericht Forschung" and other reports by the Federal Ministry for Research and Technology (BMFT).
France: Projet de Loi de Finance – Rapport annexe sur l'Etat de la Recherche et du Developpement Technologique.
United Kingdom: "Forward Look 1994" and other reports by the Office of Science and Technology.

1.1.1.4 Trends in the Share of R&D Financing among Organizations

A look at the share of R&D financing by the government and the private sector reveals that the government bore 25.3 to 32.0% in the 1960s while the private sector shouldered between 67.9 to 74.6% of the burden. In the 1970s, these figures remained stable, at 25.2 – 28.0% and 71.9 – 74.7%, respectively (Fig. 1-1-4). However, while R&D expenditures by the private sector continued to experience a steady increase of over 10% during the 1980s, with a growth of the government's share showing a decline. The government's share of the burden fell during this decade from 25.8% in FY1980 to only 16.5% in FY1990.

In the 1990s the private sector of the R&D investments decreased while the government's share of expenditures increased, until the government's share reached 20.4% in FY1993, topping the 20% mark for the first time in nine years.

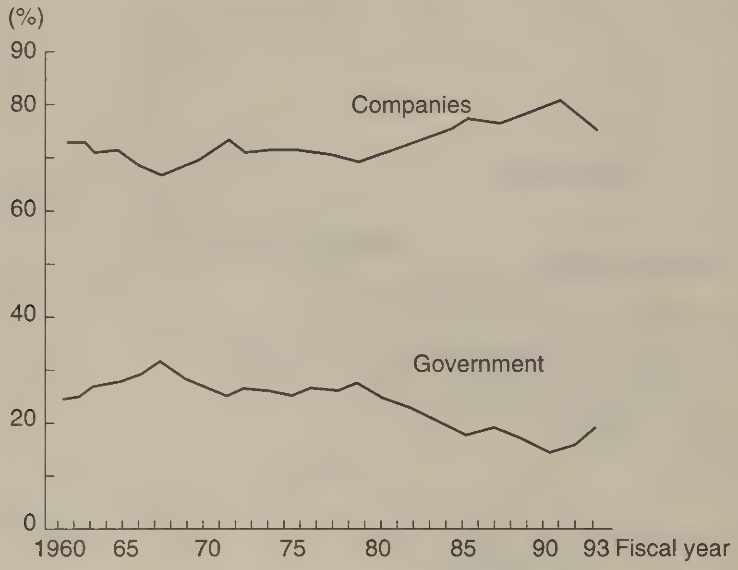

Figure 1-1-4 Trends of share in R&D financing among organizations.

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

Table 1-1-5 Trends in R&D expenditure share and ranking by industry.

Ranking	FY1960			FY1970		
	Industry	Expenditure	Share	Industry	Expenditure	Share
1	Chemical products (excluding drugs and medicines)	23,327	18.99	Communication and electronics equipment	129,845	15.77
2	Communication and electronics equipment	15,493	12.61	Chemical products (excluding drugs and medicines)	129,722	15.76
3	Electrical machinery, equipment and supplies	12,573	10.24	Electrical machinery, equipment and supplies	97,972	11.90
4	Iron and steel	8,686	7.07	Motor vehicles	78,529	9.54
5	General machinery	8,555	6.97	General machinery	72,352	8.79
6	Other transportation equipment	8,448	6.88	Drugs and medicines	45,410	5.52
7	Transport, communication and public utilities	7,362	5.99	Transport, communication and public utilities	39,100	4.75
8	Motor vehicles	6,029	4.91	Iron and steel	36,565	4.44
9	Textiles	5,480	4.46	Other manufacturing	21,504	2.61
10	Drugs and medicines	3,696	3.01	Food	21,388	2.60
11	Ceramics	3,396	2.76	Precision instruments	19,021	2.31
12	Food	3,388	2.76	Non-ferrous metals	17,872	2.17
13	Non-ferrous metals	2,967	2.42	Ceramics	17,700	2.15
14	Mining	2,510	2.04	Other transportation machinery	16,353	1.99
15	Rubber products	2,141	1.74	Construction	15,326	1.86

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

1.1.1.5 Trends in Corporate R&D Expenditures

1.1.1.5.1 R&D Expenditures

Table 1-1-5 shows trends in R&D activities comparing different industries by looking at the amount and percentage share of R&D expenditures by different industries at ten-year intervals from FY1960 to FY1990.

The chemical products industry (excluding the drugs and medicines industry) had the highest share among these industry types in FY1960 at 19.0%. However, this share continued to drop until it reached fourth place at 9.7% in FY1990. The steel industry's share, which was fourth highest in FY1960 at 7.1%, fell to ninth place in FY1990 with a share of only 3.3%.

In contrast, the communication and electronics equipment industry's share continued to increase from 12.6% (second highest) in FY1960, to 15.8% in FY1970 (passing the chemical industry to grasp the highest share), to 23.2% in FY1990, leaving it well ahead of other industries. The motor vehicles industry's share of R&D expenditures has also risen considerably, from 4.8% (8th highest) in FY1960, to 9.5% (4th) in FY1970, to 13.4% (2nd) in FY1980. Other industries which have increased their shares include the drugs and medicines, precision instrument and construction industries. The increase of R&D expenditures across industries can be discerned by looking at the transitions in the relative values for each industry when taking the R&D expenditures of FY1960 as 1 (Fig. 1-1-6).

(Table 1-1-5)

Unit: million yen (research expenditure), % (share)

Ranking	FY1980			FY1990		
	Industry	Expenditure	Share	Industry	Expenditure	Share
1	Communication and electronics equipment	535,984	17.06	Communication and electronics equipment	2,150,049	23.20
2	Motor vehicles	419,775	13.36	Motor vehicles	1,295,575	13.98
3	Chemical products (excluding drugs and medicines)	368,414	11.72	Electrical machinery, equipment and supplies	996,204	10.75
4	Electrical machinery, equipment and supplies	281,240	8.95	Chemical products (excluding drugs and medicines)	900,712	9.72
5	General machinery	218,877	6.97	General machinery	650,332	7.02
6	Drugs and medicines	189,838	6.04	Drugs and medicines	516,062	5.57
7	Transport, communication and public utilities	152,858	4.86	Transport, communication and public utilities	353,598	3.82
8	Iron and steel	147,064	4.68	Precision instruments	335,825	3.62
9	Precision instruments	99,338	3.16	Iron and steel	303,805	3.28
10	Other manufacturing	92,263	2.94	Food	217,469	2.35
11	Other transportation machinery	90,679	2.89	Ceramics	215,328	2.32
12	Food	90,237	2.87	Construction	212,677	2.29
13	Ceramics	83,222	2.65	Other transportation machinery	200,497	2.16
14	Construction	75,690	2.41	Non-ferrous metals	140,654	1.52
15	Petroleum and coal products	64,906	2.07	Fabricated metal products	129,629	1.40

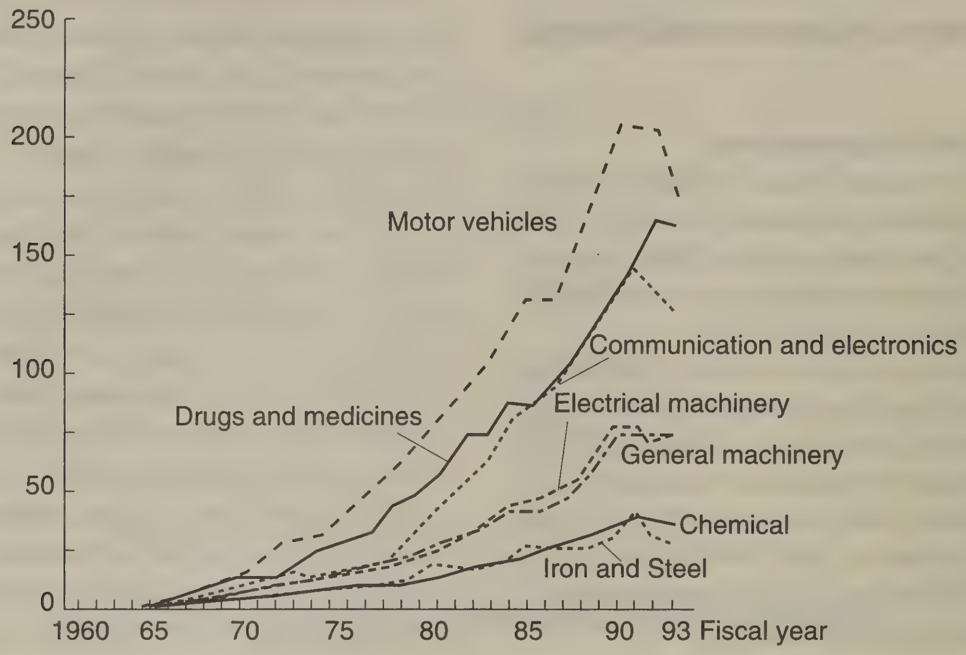

Figure 1-1-6 Trends in R&D expenditure expansion among major industries.

Note: Trends are given in relative values for each industry, with the FY1960 R&D expenditures as 1.
Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

Among leading industries, those whose R&D expenditures have shown particularly large increases (over 100 times greater in FY1990 than in FY1960) over this 30-year period include the construction industry (314.6 times greater in FY1990), motor vehicles industry (241.9), precision instruments industry (182.3), drugs and medicines industry (139.6) and the communication and electronics equipment industry (138.8). Excluding the communication and electronics equipment industry, none of these industries had a high relative share among all industries in FY1960, but have expanded their R&D activities over this 30-year period. However, the communication and electronics equipment industry, expanded on an already high relative share among all industries (2nd highest in FY1960), reaching and maintaining the number one spot.

In contrast, while industries such as the electrical machinery, equipment and supplies industry (79.2 times greater in FY1990 than in FY1960), the general machinery manufacturing (76.0), the chemical products manufacturing (40,0), the iron and steel manufacturing (35.0) and other transportation equipment industries (23.7), which had relatively large R&D expenditures in FY1960, have also steadily increased, but they have increased very little when compared to the communication and electronics equipment industry.

1.1.1.5.2 Ratio of R&D Expenditures to Sales

Figure 1-1-7 shows trends in the ratio of R&D expenditures to sales among the industries with large R&D expenditures. This ratio increased

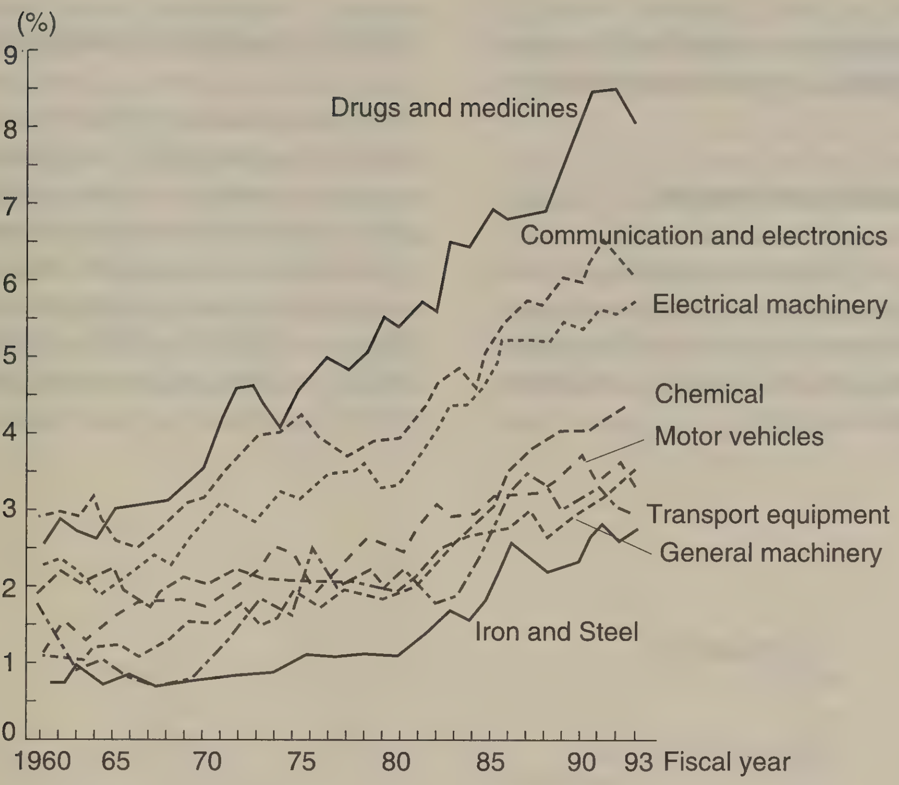

Figure 1-1-7 Trends in the ratio of R&D expenditures to sales (by industry).

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

continually as regards the drugs and medicines industry, from 2.40% in FY1960 to 4.13% in FY1970, 5.45% in FY1980 to 8.02% in FY1990.

For the communication and electronics equipment industry, this ratio increased significantly from FY1965 to FY1974, from 2.45% to 4.28%. After falling to 3.94% in FY1980 due to stagnation in the late 1970s, the ratio continued to increase greatly in the 1980s to reach 6.63% in FY1991.

The electrical machinery, equipment and supplies industry showed a similar trend by increasing from 1.81% to 3.22% from FY1963 to FY1973, decreasing slightly to 3.19% due to stagnation in the late 1970s and experiencing continuous growth from the 1980s through FY1993 when it recorded a ratio of 5.81%.

In contrast, the ratio for the iron and steel manufacturing and chemical products manufacturing (excluding the drugs and medicines industry) remained largely constant until FY1980 (iron and steel manufacturing: 0.72% in FY1960, 1.04% in FY1979; drugs and medicines industry: 1.88% in FY1960, 1.95% in FY1979), and increased greatly from the 1980s (iron and steel manufacturing: 2.72% in FY1993; chemical products manufacturing : 4.43% in FY1993). The ratio of R&D expenditures to sales increased greatly in every industry during the 1980s. It can said that the ratio of R&D activities to overall corporate activities increased during this period.

1.1.2 Research personnel

In addition to R&D expenditures, research personnel can be viewed as indicators of a society's input in research activities. This section will review the status of scientific and technological activities in society.

1.1.2.1 Number of Researchers

Persons engaged in R&D can be broadly divided into researchers[2] and support personnel (assistant research workers, technicians, and clerical and other supporting personnel).

Of these two categories, the number of researchers has risen consistently, from 82,000 in 1960 to 172,000 in 1970, 303,000 in 1980, 484,000 in 1990, and reaching 558,000 in 1994 (Fig. 1-1-8).

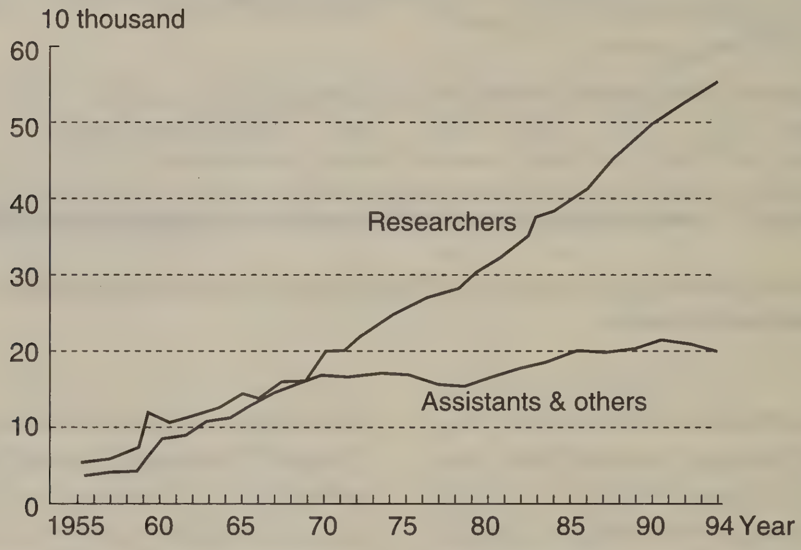

Figure 1-1-8 Changes in the number of researchers ("researchers" and "assistants and others").

Note: "Assistants and others" are defined as the sum of assistant research workers and technicians.
Source: "Report on the Survey of Research & Development" by the Statistics Bureau, Management and Coordination Agency.

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[2] "Researchers" as used in this White Paper refer only the full-time researchers, and excludes those who also perform other duties in addition to research.

Of support personnel, the number of assistant research workers and technicians rose between 1960 and 1970 (from 112,000 to 164,000). However this number has not risen as rapidly as the number of researchers, which, in fact, has since 1968 been higher than the number of assistants and technicians. After falling slightly in the 1970s, the number of assistants and technicians demonstrated a generally rising tendency in 1980s. Nevertheless, the rate of increase has been low, and a considerable gap with the number of researchers has developed.

1.1.2.2 Increases in Numbers of Researchers According to Sector

Fig. 1-1-9 shows relative increases in the number of researchers in each sector since 1960, which is assigned the arbitrary value of one. This graph shows that the number of researchers in companies and at universities rose at roughly the same rate until 1980, since which the number of researchers has risen at a higher rate in companies than at universities. The

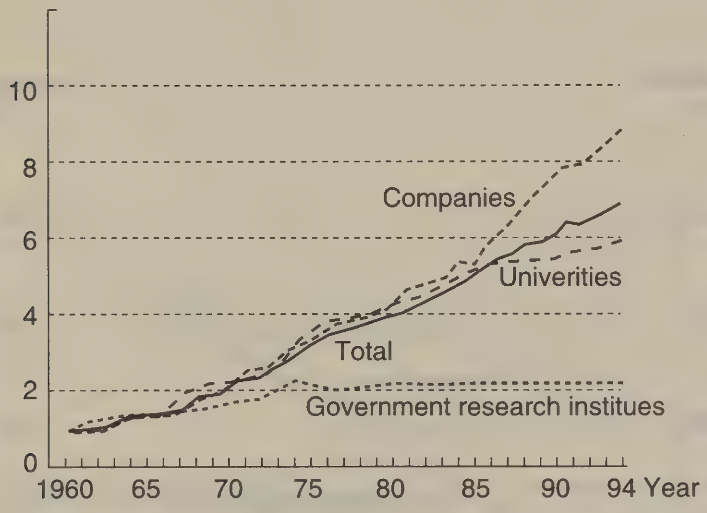

Figure 1-1-9 Changes in the number of reaearchers according to sector

Note: The numbers for each sector are the values relative to 1960, which is assigned the arbitrary value of one.

Source: "Report on the Survey of Research & Development" by the Statistics Bureau, Management and Coordination Agency.

number of researchers at government research institutes, meanwhile, until 1965 rose at roughly the same rate as in companies and at universities, and between 1965 and 1975 continued to rise, albeit at a relatively low rate. Since 1975, however, the number of government researchers has been nearly stagnant, resulting in a large gap with the other two sectors.

1.1.2.3 Number of Researchers per 10,000 Population and per 10,000 Labor Force

The number of researchers per 10,000 of the population continued to increase from 8.7 people in 1960 to 16.4 in 1970, 25.8 in 1980, and 39.2 in 1990 (Fig. 1-1-10).

The number of researchers per 10,000 labor force increased similarly during these years, from 18.2 people in 1960 to 33.4 in 1970, 53.6 in 1980, and 75.9 in 1990. These indicators show the ratio of people involved in research in the society, and since these numbers are steadily increasing, it can be surmised that the portion of social activities occupied by research activities has also been steadily increasing.

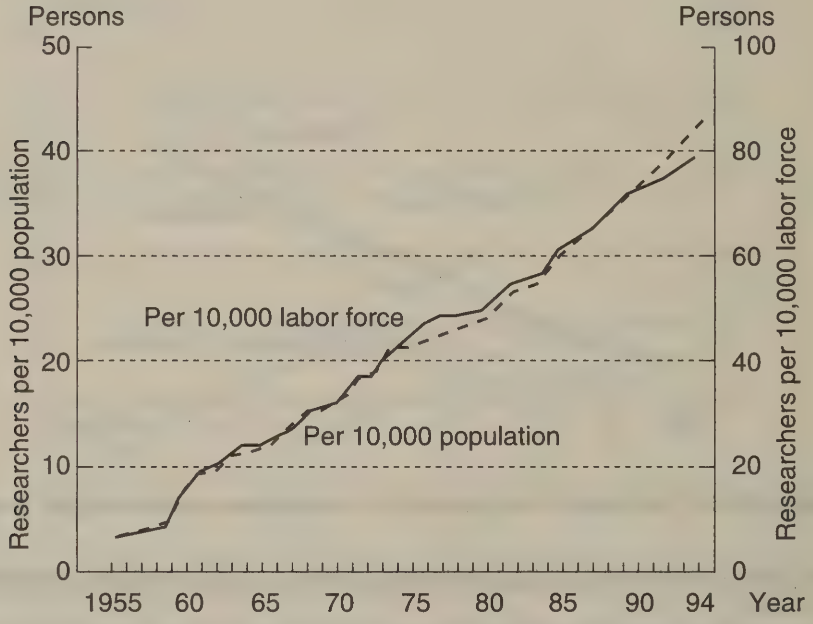

Figure 1-1-10 Trends in the number of researchers per 10,000 population and per 10,000 labor force.

Sources: Prepared by the Science and Technology Agency, based on "Report on the Survey of Research and Development," "Population Estimates Series," "Report on the Labor Force Survey" and "National Census" by the Statistics Bureau, Management and Coordination Agency.

1.1.2.4 Ratio of Researchers to Total People Employed in Industries

The ratios of researchers to total people employed in the chemical products (excluding the drugs and medicines industry), communication and electronics equipment industries continue to steadily increase, with the highest ratios ever among all industries (chemical products industry: 2.03% in 1960, 3.30% in 1970,5.44% in 1980 and 10.07% in 1994; communication and electronics equipment industry: 3.13% in 1960, 3.30% in 1970, 6.56% in 1980 and 12.29% in 1994). (Fig. 1-1-11).

The drugs and medicines and electrical machinery, equipment and supplies industries also showed continuing steady increases (from 3.66% in 1960 to 9.47% in 1994 for the drugs and medicines industry, and from 1.45% in 1960 to 8.78% in 1994 for the electrical machinery, equipment and supplies industry). These types of industries have comparatively high degrees of dependency on new technology and thus their degrees of dependency on R&D personnel have also been growing.

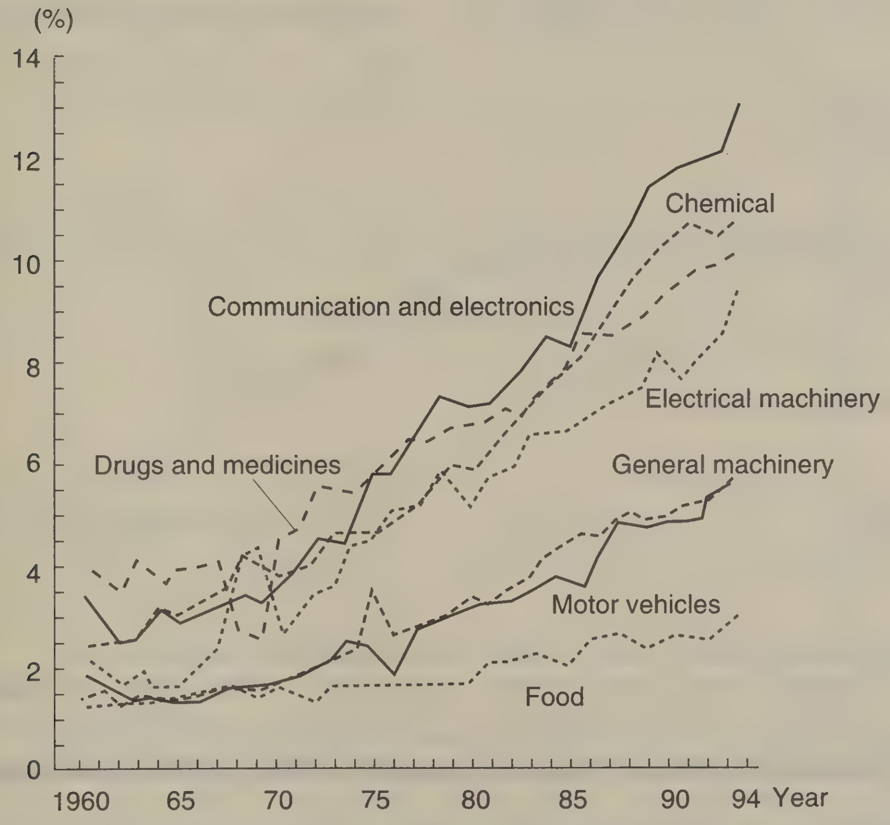

Figure 1-1-11 Ratio of researchers to total people employed in industries.

Source: “Report on the Survey of Research and Development” by the Statistics Bureau, Management and Coordination Agency.

1.1.2.5 Number of Assistant Research Workers and Technicians per Researcher

The number of assistant research workers and technicians per researcher continues to decrease, due to a lack of growth in the number of assistant research workers and technicians. At the same time, there has been an increase in the number of researchers. There were 1.36 assistant research workers and technicians per researcher in 1960, but the number continued to decrease to 0.95 in 1970, 0.53 in 1980 and 0.43 in 1990 (Fig. 1-1-12).

1.1.2.6 Education of Scientific and Technological Personnel

One of the basic elements essential for the development of science and technology is to have capable personnel in this field. It was the presence of outstanding researchers and engineers who had received their training in educational courses in science and engineering that sustained the development of postwar scientific and technological activities in Japan. A general picture of the changes in this essential element, which sustained the development of postwar science and technology, is presented here and is based on trends in the development of scientific

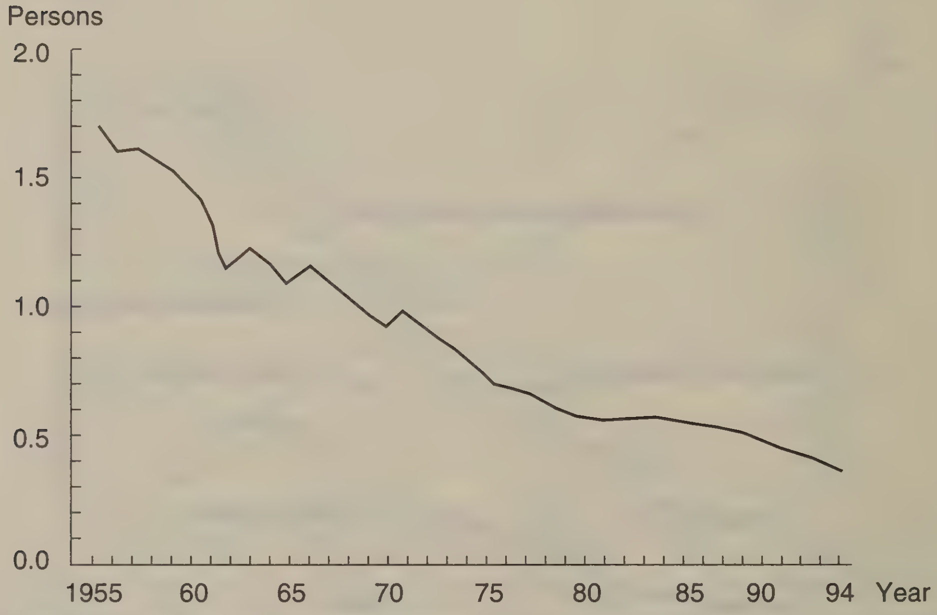

Figure 1-1-12 Trends in the number of assistant research workers and technicians per researcher.

Note: Total of assistant research workers and technicians per researcher.
Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

and technological personnel in the educational institutions.

1.1.2.6.1 Ratio of Students Going on to High School

The ratio of students going on to high school (the ratio of middle school graduates going on to high school excluding those taking regular courses in correspondence school curricula) rose year by year from 42.5% in 1950 to 82.1% in 1970 and 94.2% in 1980, and since then has tended to remain more or less the same (Fig. 1-1-13).

1.1.2.6.2 Ratio of Students Going on to Universities

There are fluctuations in the ratios of students going on to universities (academic faculties/departments) due to rises and falls in the population of 18 year-olds, but on the whole ratios continued to increase up until the middle of the 1970s, going from 7.9% in 1955 to 27.3% in 1976. After 1976, there was a decline in the ratio of males going on to universities. The rates went from 40.9% in 1976 to 34.2% in 1986, while the aggregate ratio decreased to 23.6% in 1986 (Fig. 1-1-14).

There was, however, a great increase in the ratios of female students going on to universities starting from the latter half of the 1980s. The ratio increased from 12.5% in 1986 to 21.0% in 1994 and as a result, the aggregate ratio of students going on to universities began to increase, reaching 30.1% in 1994.

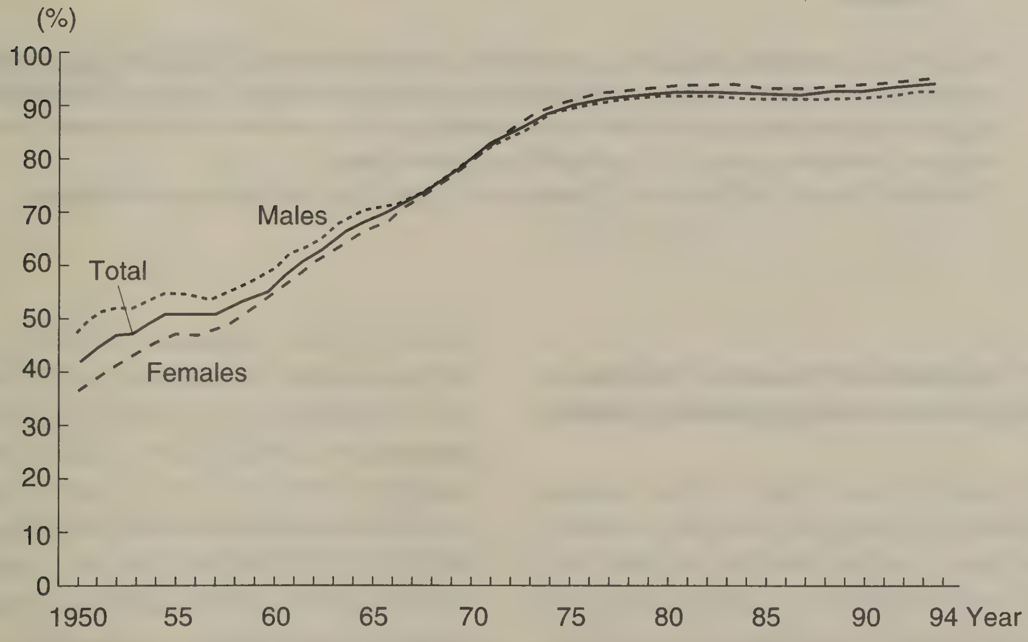

Figure 1-1-13 Ratio of students going on to high school (excluding those taking regular courses in correspondence schools).

Note: Percentages of students going on to high school comprise middle school graduates who go on to regular or special courses in high school or to technical colleges (also includes those who work at the same time they go on to high school, but not those who wish to go on but who so far have failed to be admitted).

Source: "Statistical Abstract of Education, Science and Culture" by the Ministry of Education.

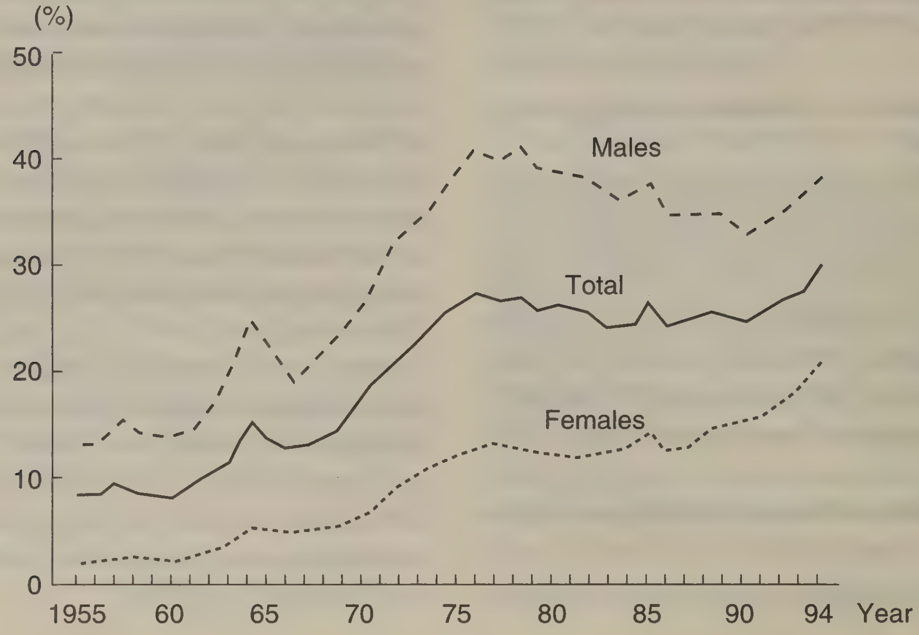

Figure 1-1-14 Trends in ratios of students going on to universities (academic faculties/departments).

Note: The ratios of students going on to universities (academic faculties/departments) are ratios derived by dividing the number of students enrolled in universities (excluding those who wish to go on but who have so far failed to be admitted) by the number of middle school students who are three years away from university enrollment level.

Source: "Statistical Abstract of Education, Science and Culture" by the Ministry of Education.

1.1.2.6.3 Numbers of Students Enrolled in University Science and Engineering Departments

In the ensuring years, there will be capable scientific and technological personnel available, finding if these people who are creative and adaptable and are able to train others is just as essential as securing a sufficient number of personnel. University science and engineering departments are important for their role in training future scientific and technological personnel.

Released in October 1960, Recommendation No. 1 of the Council for Science and Technology, titled "Comprehensive and Fundamental Measures for the Development of Science and Technology for 10 Years Ahead, "and the government's "Plan to Double Incomes" predicted that the number of graduates of university science, engineering, agriculture, and medical departments would fall short of actual demand by roughly 170,000 over the next ten years, and called for the immediate formulation and implementation of a detailed plan for increasing the number of science and engineering students. In response, the Ministry of Education released and implemented its "Plans to Increase the Number of Science and Engineering Students" between 1961 to 1963 to achieve the goals it had set.

The number of students enrolled in university science, engineering and related departments (which encompasses departments of science, engineering, agriculture, and health/medicine) was 38,000 in 1960 but between 1961 and 1963 grew at an annual rate of over 10%, reaching 55,000 by 1963 (Fig. 1-1-15).

1.1.2.6.4 Ratios of Students in Science and Engineering

Let's take a look at the increases in students in science and engineering in terms of the proportion of students enrolled in science and engineering departments to total enrolled students (Fig. 1-1-16). The number of students enrolled in science and engineering departments was 19.9% of all students enrolled in 1956, but this rapidly increased to 23.0% in 1960 and 26.2% in 1964. It continued to increase steadily after that and reached 30.1% in 1969, but since 1970 it has tended to remain within the 28.3 – 31.7% range. The increase in the ratio of students in science and engineering from the latter half of the 1950s to the first part of the 1960s may be a characteristic trend.

1.1.2.6.5 Numbers of Doctoral Degree Recipients

The number of doctoral degree recipients may be one of the important indicators used for evaluating the quality of scientific and technological personnel. The numbers of doctoral degree holders in science and engineering faculties have increased greatly, with 240 people in 1960 and 1463 people in 1970. This is an increase of 6.1 times over the ten year period (Fig. 1-1-17). There was a marked increase in recipients of doctoral degrees on the basis of dissertations alone in the first half of the 1960s, which went from 29 people in 1960 to 520 in 1965. On

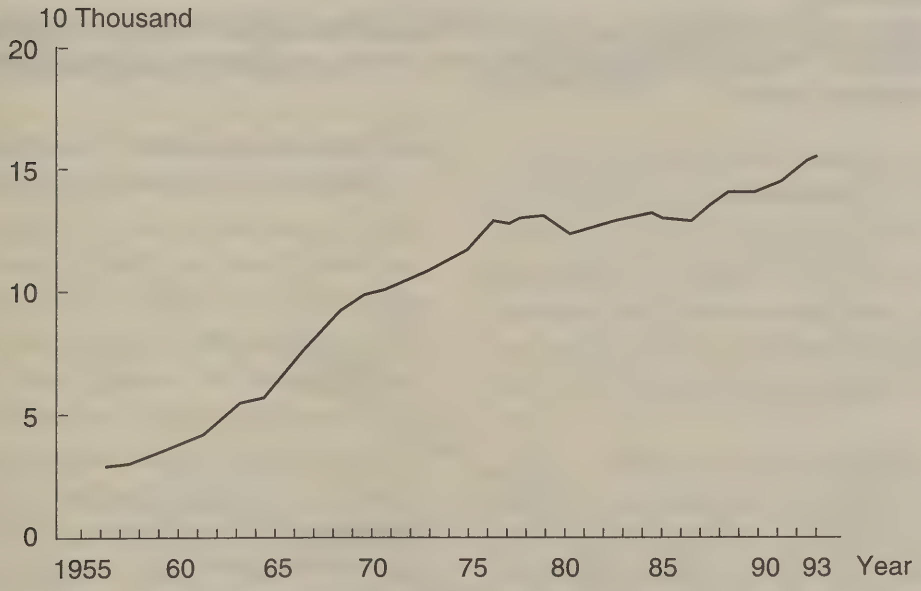

Figure 1-1-15 Changes in the number of students enrolled in university science and engineering departments

Note: Figures for 1967 and before are the total enrollees in departments of science, engineering and agriculture. Figures for 1968 onward are the total enrollees in departments of science, engineering, agriculture, and health/medicine.

Sources: "Report on School Basic Survey" by the Ministry of Education. "Science and Technology Indicators (1994)" by the National Institute of Science and Technology Policy, Science and Technology Agency.

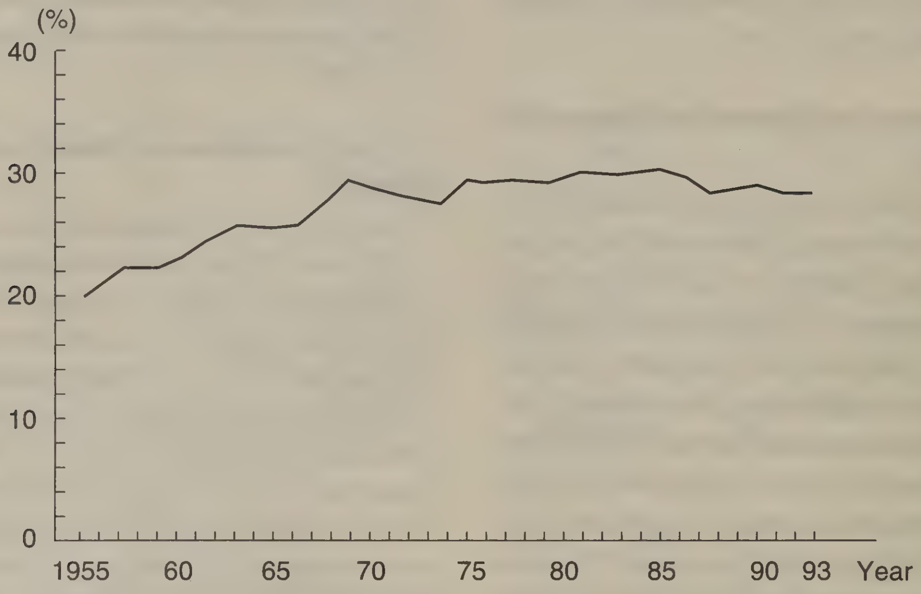

Figure 1-1-16 **Trends in ratios of students enrolled in the science and engineering departments to the total number of students enrolled in universities.**

Note: Refer to Fig. 1-1-15 for number of students enrolled in university science and engineering departments.

Sources: "Report on School Basic Survey" by the Ministry of Education. "Science and Technology Indicators (1994)" by the National Institute of Science and Technology Policy, Science and Technology Agency.

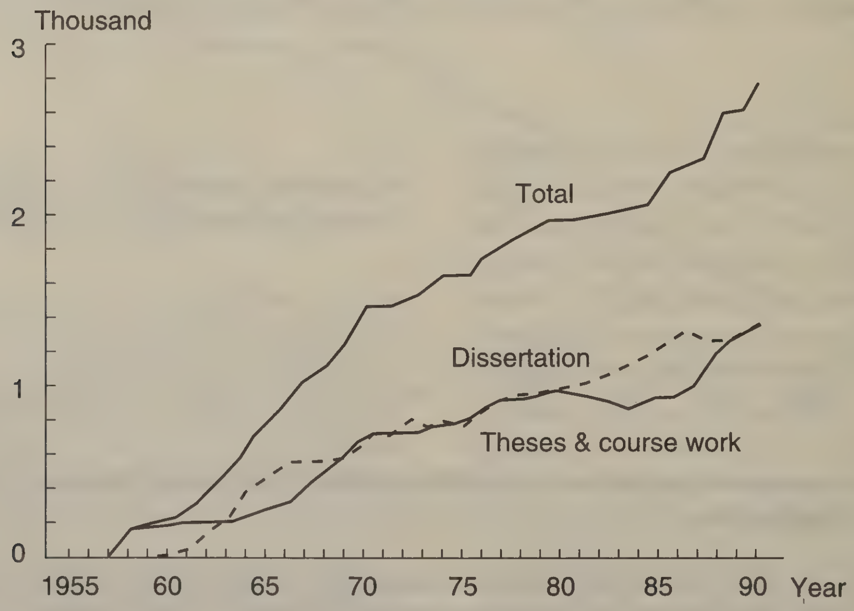

Figure 1-1-17 **Trends in recipients of doctoral degrees (science and engineering faculties).**

Source: "Science and Technology Indicators (1994)" by the National Institute of Science and Technology Policy, Science and Technology Agency.

the other hand, the number of doctorates awarded on the basis of full course work and a thesis increased greatly in the latter half of the 1960s, going from 315 in 1965 to 748 in 1970. People receiving both types of doctoral degrees continued to show moderate increases in the 1970s, but going into the 1980s the number of doctoral degrees on the basis of dissertations alone continued its comparatively smooth upward climb while doctorates awarded on the basis of full course work and a thesis showed a downturn. In the latter half of the 1980s, though, doctorates awarded on the basis of full course work and a thesis showed a rapid upturn and in 1990 there were 1,404 recipients, whereas there were 1,398 recipients of doctoral degrees awarded on the basis of dissertations alone.

1.1.3 Internationalization of Research Activity

1.1.3.1 International Exchanges of Scientific and Technological Personnel

1.1.3.1.1 Number of Researchers and Engineers Entering and Leaving the Country

As social and economic globalization continues, research activity is also becoming more and more internationalized. At the same time, Japan is being called on to play an international role in rescarch and development that is more commensurate with its economic influence.

Here, interchange among researchers and engineers[3] will be analysed by examining changes in the number of researchers and engineers entering and leaving the country (Fig. 1-1-18). The number of researchers and engineers entering the country and the number leaving the country rose at roughly the same gradual rate in the mid-1980s, since which both have been increasing at considerably high rates.

1.1.3.1.2 Number of Scientists and Engineers Entering and Leaving Japan by Region

Of the number of scientists and engineers entering and leaving Japan by region, the number entering Japan from other parts of Asia has increased rapidly since 1981. The number leaving Japan for other parts of Asia also rose in the latter half of the 1980s, but was greatly exceeded by the number entering (Fig. 1-1-19 (1)).

On the other hand, the number of scientists and engineers leaving Japan for North America and Europe has shown a large increase since the latter half of the 1980s, while the number of those entering Japan has also increased, although only slightly (Figs. 1-1-19 (2), 1-1-19 (3)).

1.1.3.2 Number of International Conferences Held

Since international conferences on science and technology serve as forums where the results of a country's research are made known to the world and since they also provide the opportunity for international interchange among researchers, these conferences indicate the degree to which research has been internationalized.

The number of international conferences held on science and technology varies from year to year (conference figures used here are combined totals from "Convention Statistics," collected by the Japan National Tourist Orga-

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[3] In this White Paper, scientists and engineers are people entering and leaving Japan under the following categories of the Immigration Control and Refugee Certification Act.
Travel objectives of Japanese citizens leaving the country: academic research, inquiry, study abroad, study and training, technological proficiency.
Reasons for residence of foreigners entering the country: study abroad, study and training, teaching activity, artistic or academic activity, providing a high degree of technical expertise (until 1989); study abroad, study and training, teaching, research, technological expertise (since 1990).

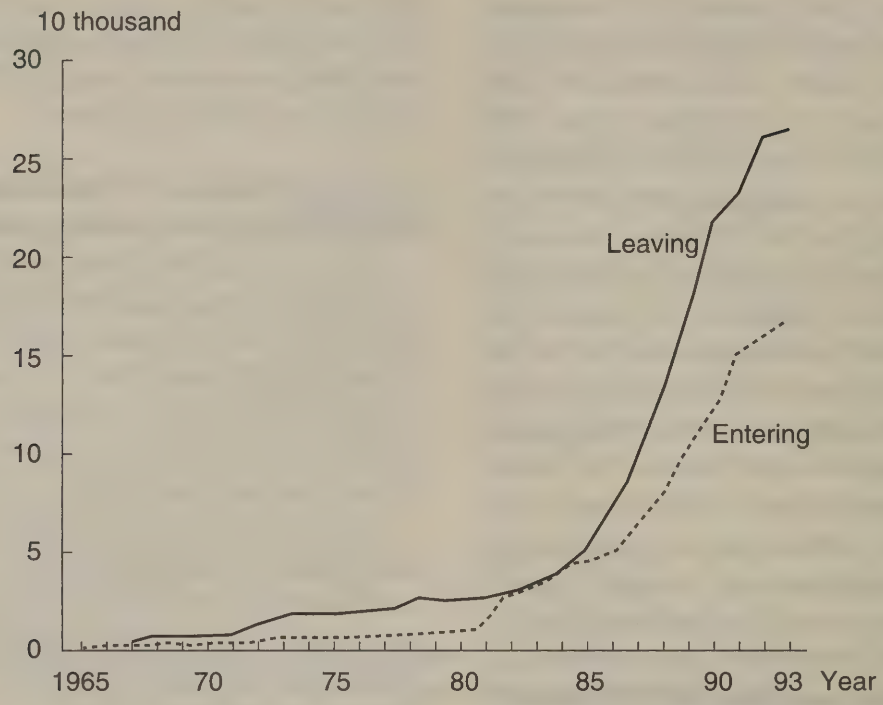


Figure 1-1-18 **Changes in the number of researchers and engineers entering and leaving the country.**

Note: "Researchers and engineers" refers to the sum of the totals for each category of persons leaving and entering the country, used in the Ministry of Justice's "Immigration Control Statistics." (This is the statistical method used by the National Institute of Science and Technology Policy in its "Science and Technology Indicators.")

(1)Objectives of Japanese leaving Japan
1. Academic research or inquiry
2. Education, training, or skill acquisition
(2) Residence status of foreigners entering Japan
- Up to 1989 -
1) Education. 2) Training. 3) Instruction. 4) Artistic or academic activity.
5) Providing an advanced skill
- 1990 and beyond -
1) Education. 2) Training. 3) Instruction. 4) Reaearch. 5) Technology
Persons with the residence status "training" are not included in the totals for 1981 or earlier.

Sources: "Science and Technology Indicators (1994)" National Institute of Science and Technology Policy, Science and Technology Agency.
"Immigration Control Statistics" by the Ministry of Justice.

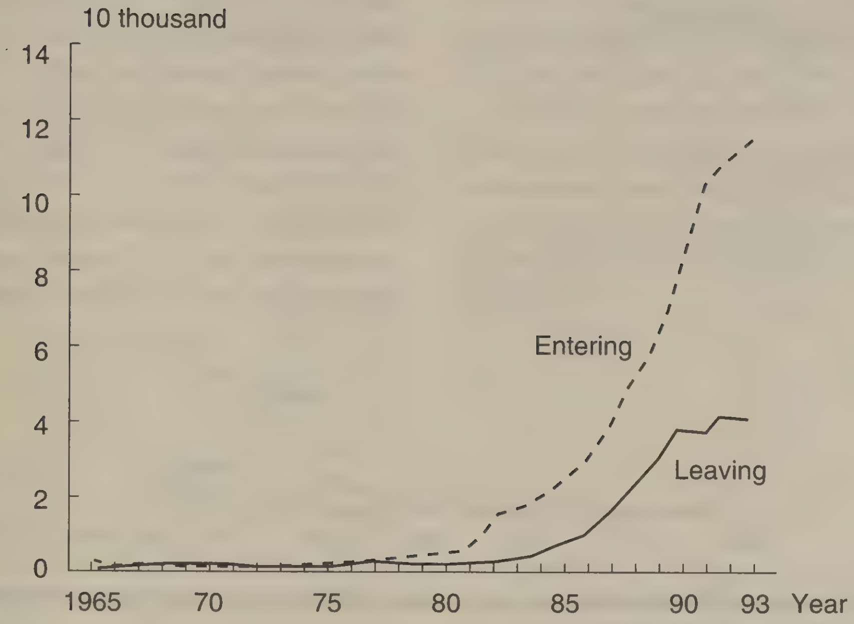


Figure 1-1-19(1) Number of scientists and engineers entering and leaving the country by region (from or for Asia).

Sources: "Science and Technology Indicators (1994)" by the National Institute of Science and Technology Policy, Science and Technology Agency. "Immigration Control Statistics" by the Ministry of Justice.

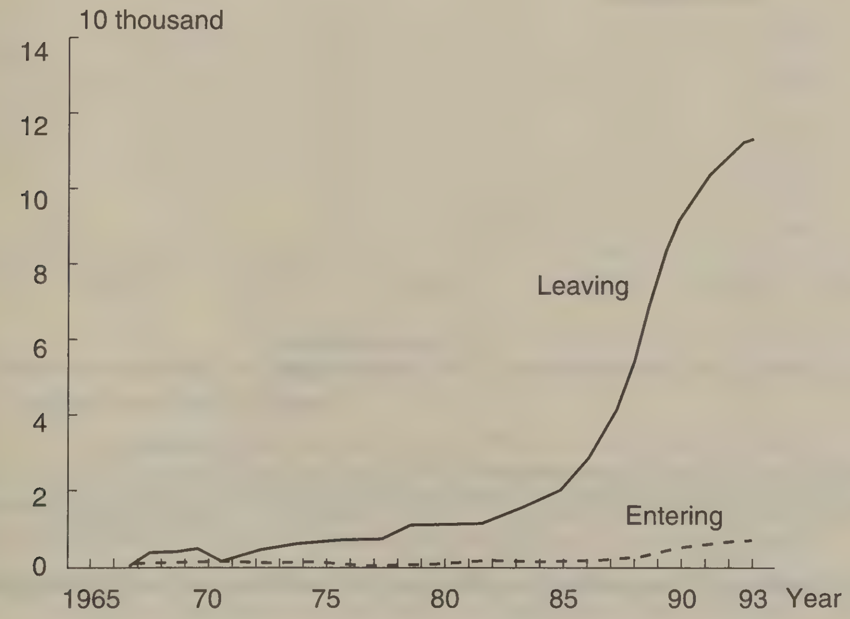


Figure 1-1-19(2) Number of scientists and engineers entering and leaving the country by region (from or for North America).

Sources: "Science and Technology Indicators (1994)" by the National Institute of Science and Technology Policy, Science and Technology Agency.
"Immigration Control Statistics" by the Ministry of Justice.

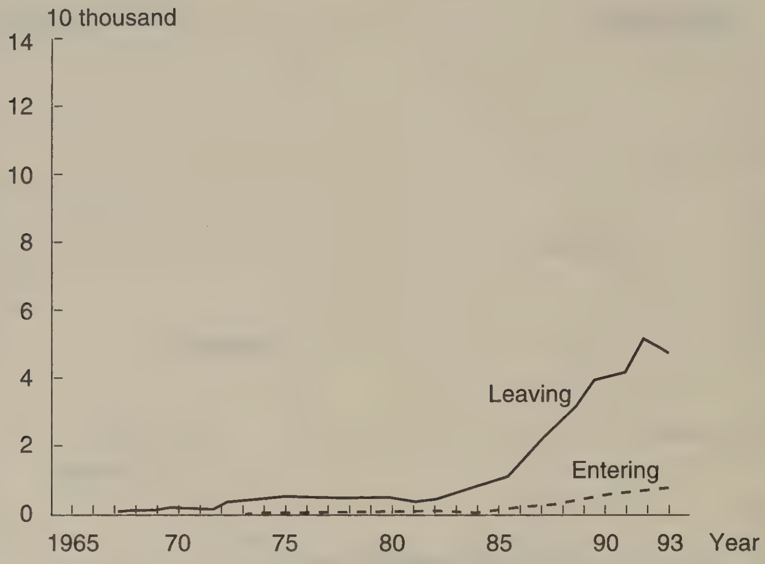


Figure 1-1-19(3) Number of scientists and engineers entering and leaving the country by region (from or for Europe).

Sources: "Science and Technology Indicators (1994)" by the National Institute of Science and Technology Policy, Science and Technology Agency. "Immigration Control Statistics" by the Ministry of Justice.

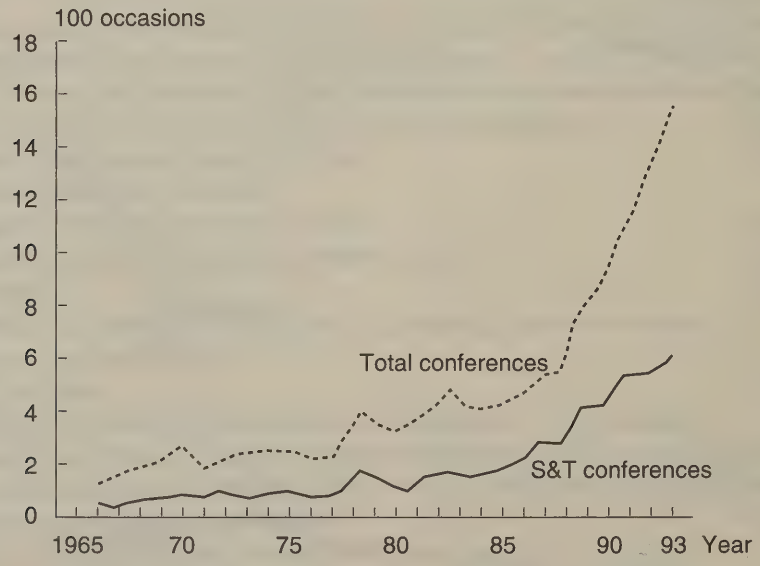


Figure 1-1-20 Number of international conferences on science and technology held in Japan.

Notes: 1. Number of international conferences, seminars, symposia, etc., at which there were 20 or more participants from two or more countries, including Japan.

2. "S&T Conferences" are the total number of conferences in the areas of science and technology and medical science.

Sources: "International Conference Statistics," 1966~1984, Japan National Tourist Organization. "Convention Statistics," 1985~present, Japan National Tourist Organization.

nization, international conferences, seminars and symposia with 20 or more participants from two or more countries, including Japan, in the areas of science and technology and medical science). From 1966 to 1970 there were from 29 to 70, from 1971 to 1975 there were 61 – 83, from 1976 to 1980 there were 68 – 166 and from 1981 to 1985 there were 145 – 190 conferences, with a continuing steady rise in number (Fig. 1-1- 20). There were large increases in the latter half of the 1980s with 261 conferences in 1986, 402 in 1988 and 520 in 1990.

The ratio of international conferences on science and technology to the total number of international conferences held has also increased from 29.1% for the period from 1966 to 1970 to 48.8% for the period from 1986 to 1990 (Fig. 1-1-21).

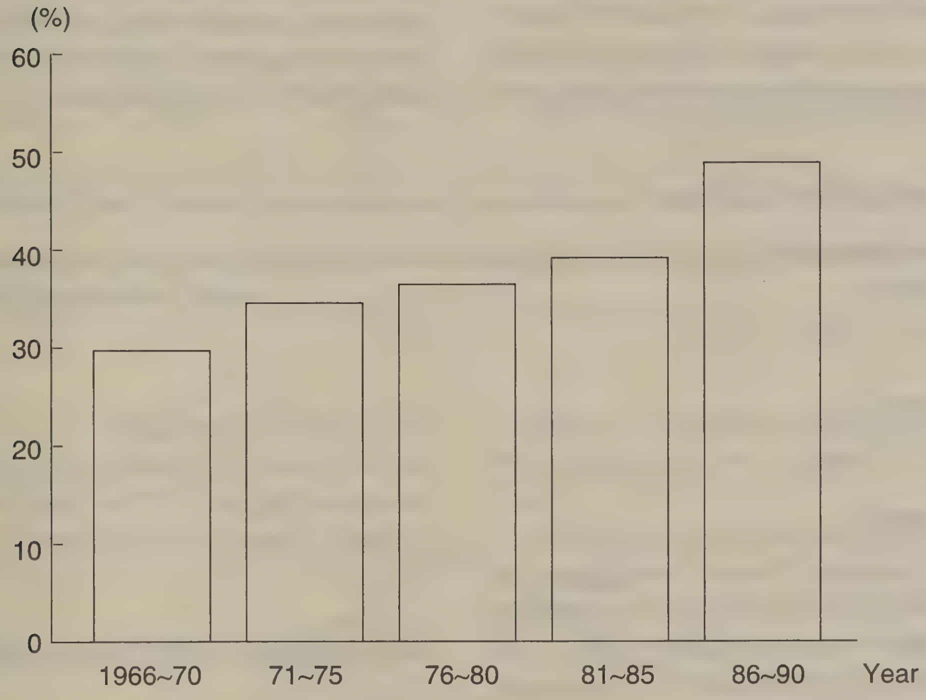


Figure 1-1-21 Ratios of number of international S&T conferences to the number of international conferences held in Japan.

Note: See Fig. 1-1-20 for method of calculating the total number of international conferences.
Sources: "International Conference Statistics," 1966～1984, Japan National Tourist Organization.
"Convention Statistics," 1985～present, Japan National Tourist Organization.

1.1.4 Technology Trade with Other Nations

1.1.4.1 Trade in Technology

1.1.4.1.1 Trends in Technology Trade

Trends in the number of technology exports and imports (Fig. 1-1-22) and the "Report on the Survey of Research and Development" by the Statistics Bureau of the Management and Coordination Agency show that technology import amounts have, as a whole, continued to moderately increase. By contrast,technology export amounts increased and overtook the amount of technology exports for FY1982 – FY1984, declined in FY1984 – FY1987 and then continued a large scale increase starting in FY1988.

1.1.4.1.2 Trends in the Ratio of Technology Exports to Imports

The ratio of technology exports to imports was 0.20 in 1971, an overwhelming excess of imports over exports, but the continuous rise of technology exports throughout the 1970s and early 1980s brought this ratio up to 0.99 by 1984. (Fig. 1-1-23) The excess of imports over exports continued in subsequent years due to stagnant technology exports, but by 1989 the ratio was approaching one; imports still exceeded exports, but by a small amount.

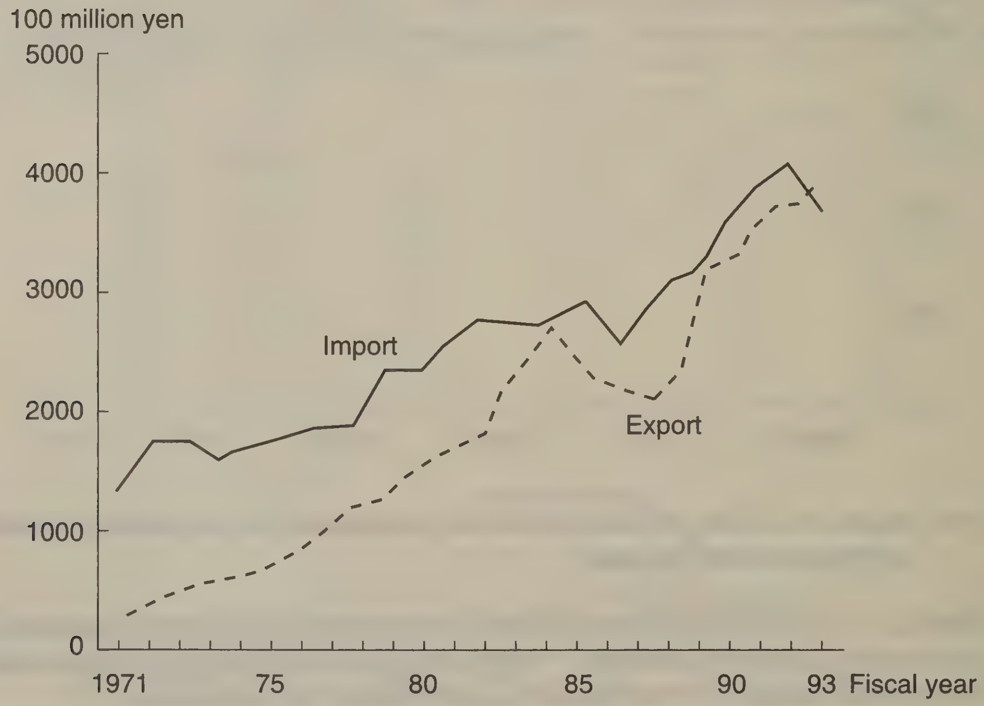


Figure 1-1-22 Changes in technology exports and imports

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

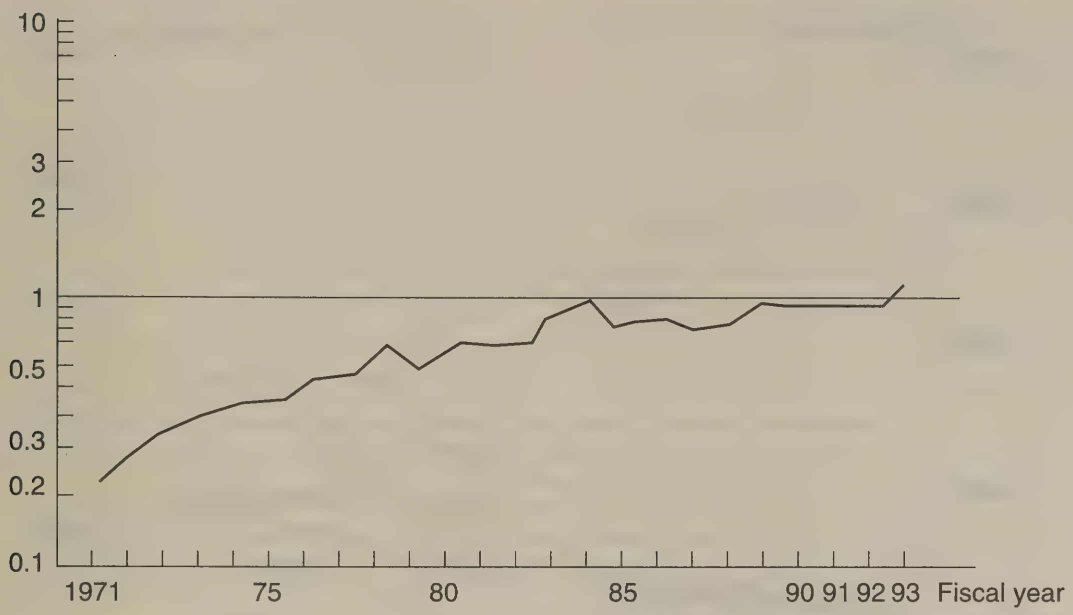


Figure 1-1-23 Trends in the balance of technological trade (exports/imports).

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

In 1993, a rise in technology exports and a drop in imports combined to produce an export-to-import ratio of 1.10, the first excess of exports over imports since the survey was begun in 1972.

1.1.4.2 Technology Trade Amounts by Region

An examination of the large amounts of technology trade with Asia, North America and Europe follows (Figs. 1-1-24, 1-1-25). Technology export amounts to Asia continued to rise until the middle of the 1980s, were sluggish through FY1985 – 1987, and then continued to rise sharply from FY1988 onwards. Viewed in terms of the balance of technological trade (export-to-import), the trend is one of great export surplus (Fig. 1-1-26).

Regarding technology trade with Europe, there was a general moderate increase in the amounts of both exports and imports, with a moderate expansion of a surplus of imports from Europe in the balance of technological trade.

The amounts of technology exports to North America have overall increased, but import amounts of technology from North America have also increased greatly. On the whole, there was an expansion of a surplus of imports from North America in the balance of technological trade.

1.1.4.3 Technology Trade Amounts in Selected Industries

Technology export amounts for selected industries in Japan from the middle of the 1980s notably increased for the mortor vehicles industry and the communication and electronics equipment industries (Fig. 1-1-27).

Communication and Electronics equipment industry technology import amounts increased greatly during FY1979 – FY1982 and FY1987 –

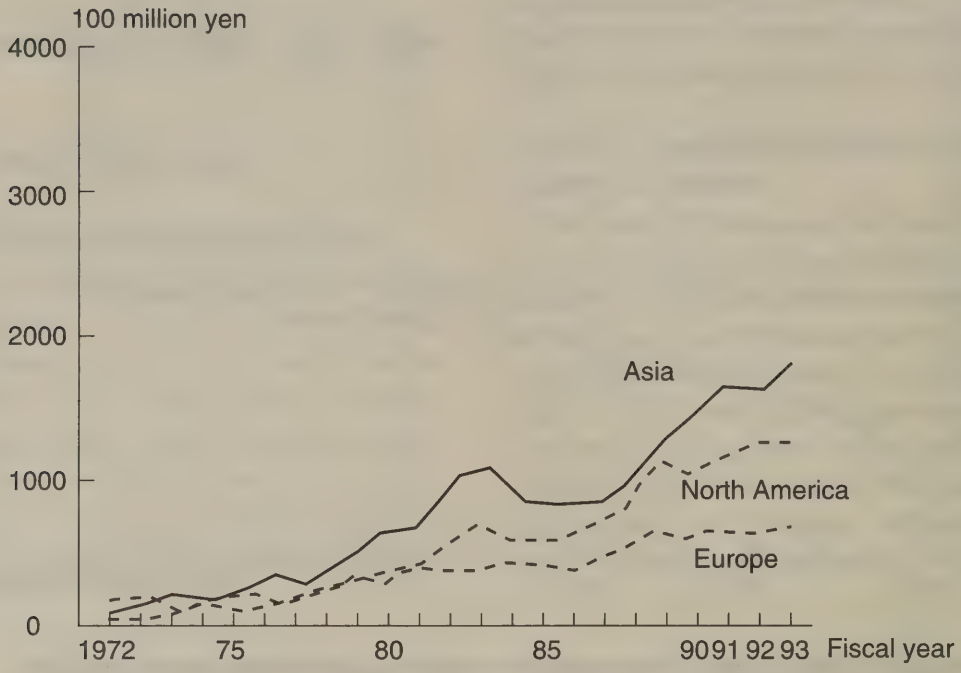


Figure 1-1-24 Trends in technology exports by region.

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

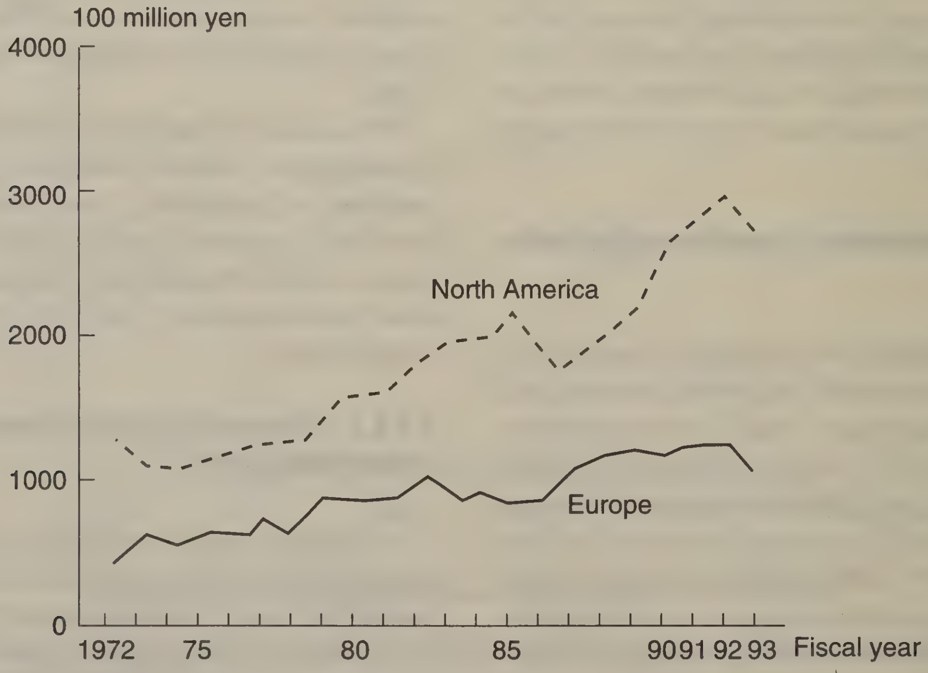


Figure 1-1-25 Trends in technology imports by region.

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

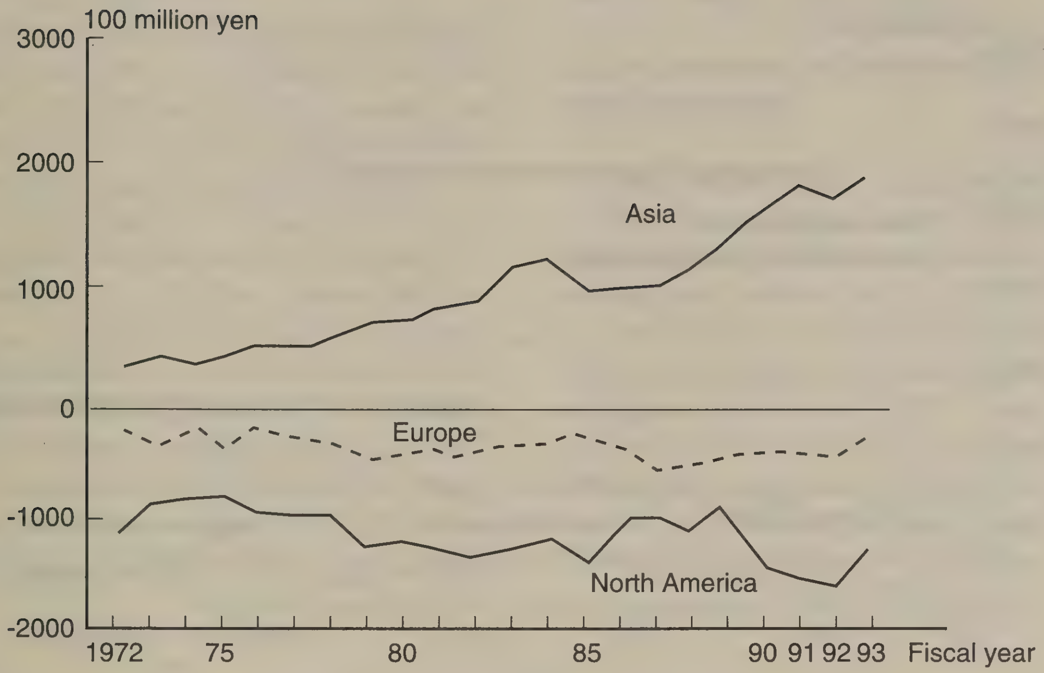


Figure 1-1-26 Trends in the balance of technological trade (export-to-import) by region.

Source: “Report on the Survey of Research and Development” by the Statistics Bureau, Management and Coordination Agency.

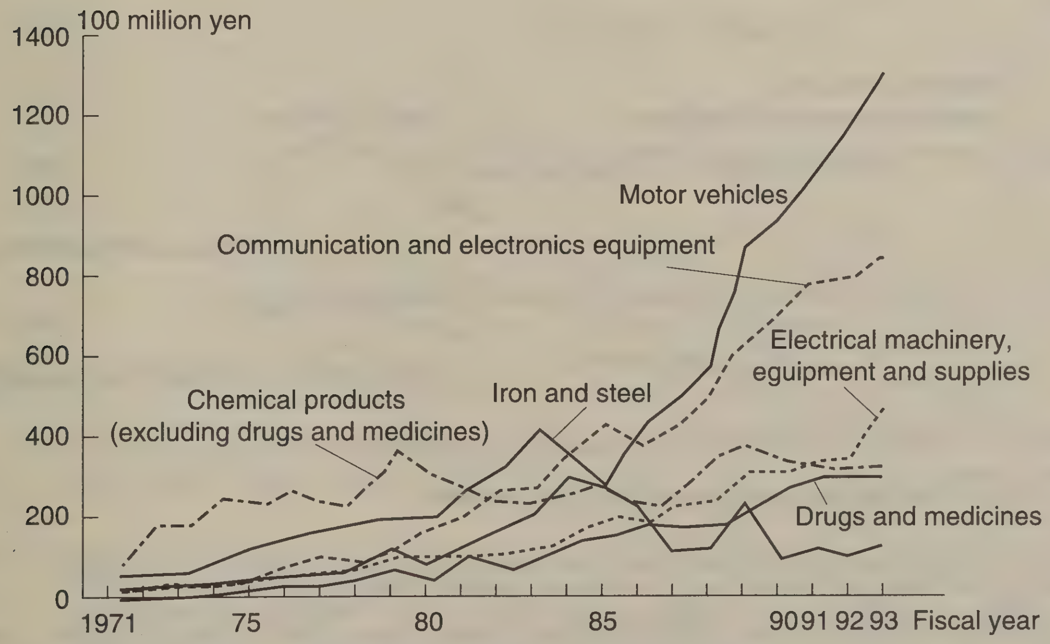


Figure 1-1-27 Trends in technological exports in selected industries.

Source: “Report on the Survey of Research and Development” by the Statistics Bureau, Management and Coordination Agency.

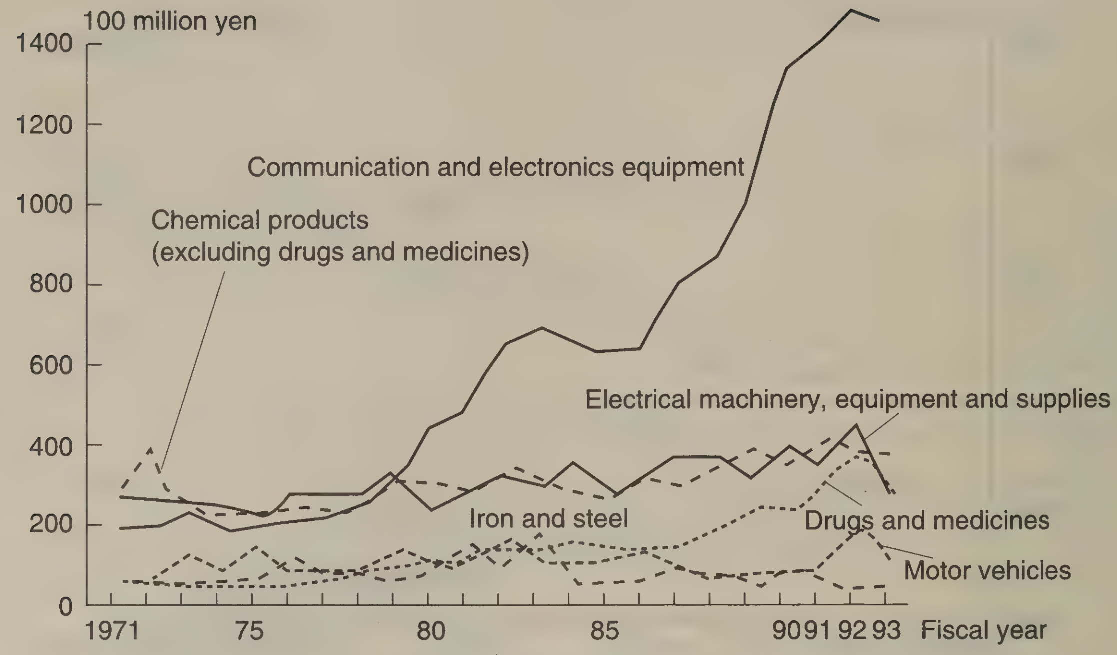


Figure 1-1-28 Trends in technological imports in selected industries.

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

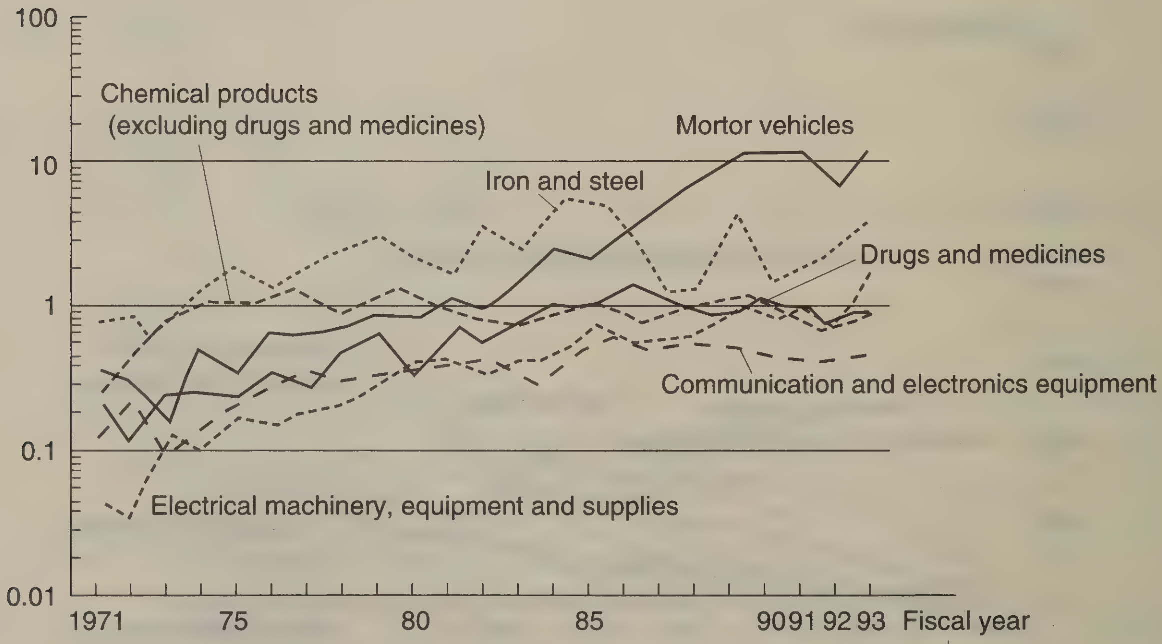


Figure 1-1-29 Trends in technology trade balance of selected industries.

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

FY1990 (Fig. 1-1-28).

There was a switch to an export surplus in the first half of the 1980s in the balance of technology trade in the mortor vehicles industry and since then the size of the export surplus has been experiencing an ongoing expansion. In FY1974, the iron and steel industry experienced a transition to an export surplus that peaked out in FY1984 (Fig. 1-1-29). The chemical products and drugs and medicines industries showed a gradual reduction in import surpluses in the 1970s and reached a general equilibrium in the balance of technology trade starting in 1984.

The communication and electronics equipment industries, on the other hand, greatly expanded their technology trade export surplus from the middle of the 1980s.

1.1.4.4 Number of Introductions of Foreign Technology

In the middle of the 1970s, the rate for the introduction of foreign technology declined temporarily, but soon after resumed a general tendency to increase (Fig. 1-1-30).

A breakdown of the trend indicates that for instances of software and non-software technology introduction since FY1971, cases of software introduction increased greatly, while non-software cases decreased slightly. Increases in the introduction of technology from FY1980 on were almost entirely due to software.

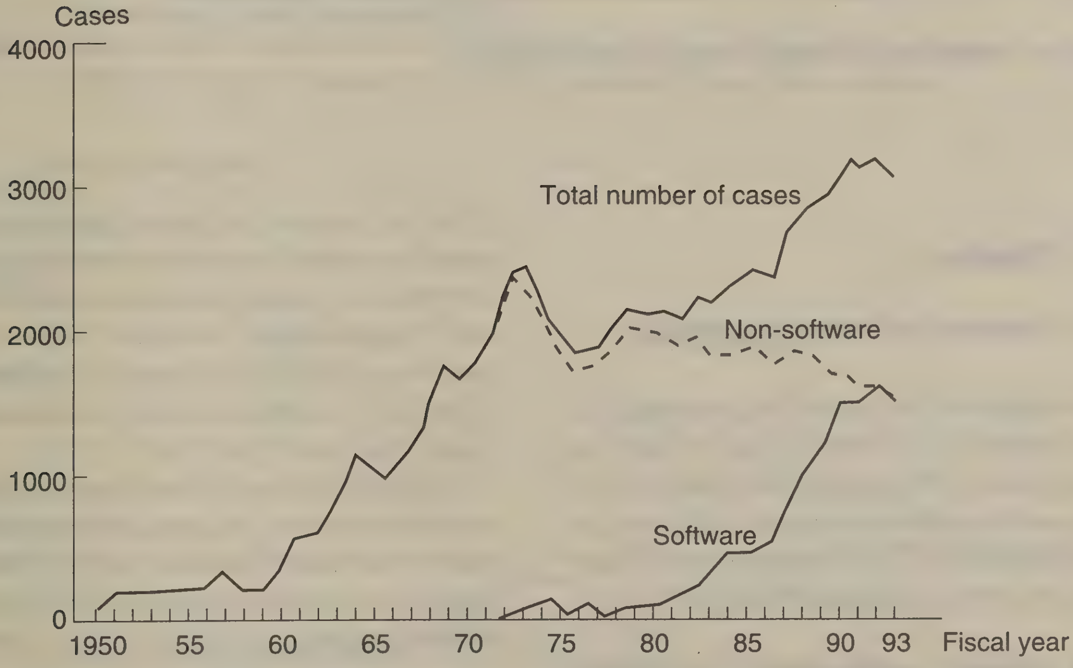


Figure 1-1-30 Trends in the number of introductions of foreign technology.

Sources: "Annual Report on Technology Imports (through FY1986)," Science and Technology Agency. "Summary of Technology Imports (FY1987 ~FY1989)," National Institute of Science and Technology Policy, Science and Technology Agency. "Analysis of Trends in Technology Imports (FY1990 ~present)," National Institute of Science and Technology Policy, Science and Technology Agency.

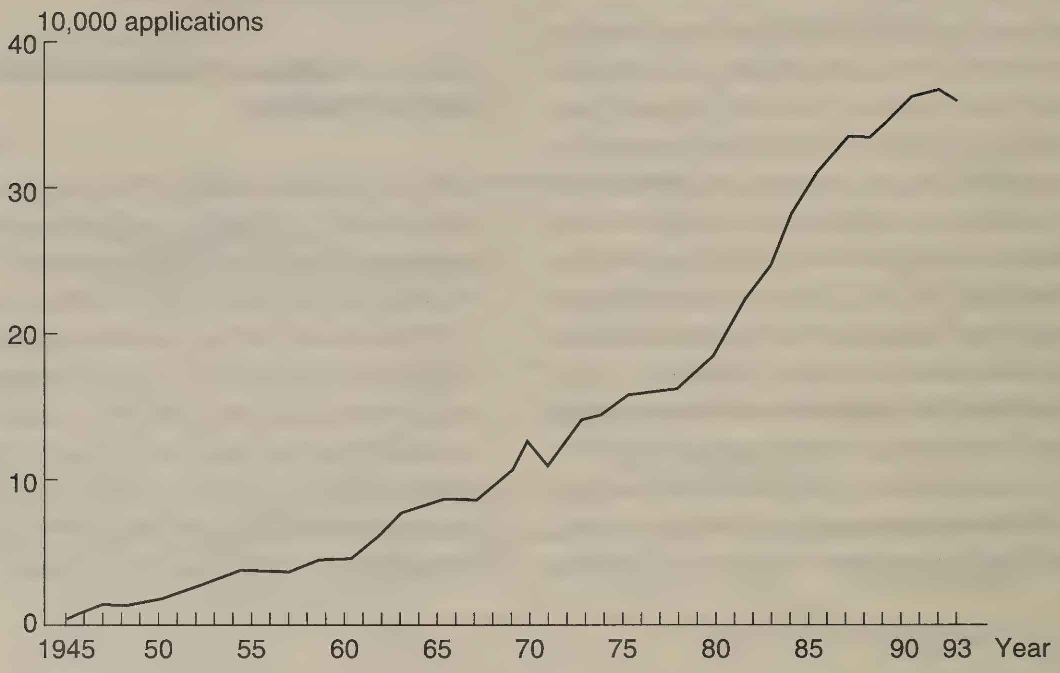


Figure 1-1-31 Trends in the number of patent applications.

Source: "Patent Agency Yearbook" by the Patent Agency.

1.1.5 Patents

1.1.5.1 Number of Patent Applications

The increase in the number of patent applications submitted by Japanese in our country was sluggish in the 1970s, but still continued on the whole, and then showed a particularly rapid increase in the 1980s. The increase slowed, however, in the latter half of the 1980s (Fig. 1-1-31).

1.1.5.2 Patent Applications in Foreign Countries (Number of Patent Applications)

The number of patent applications submitted in foreign countries by Japanese rapidly increased in the 1980s after a sluggish period in the 1970s. This increase has slowed in the 1990s (Fig. 1-1-32).

For the number of patent applications submitted in selected countries taken from the total submitted in foreign countries, while the number of applications submitted in the United States was temporarily sluggish in the latter half of the 1970s, there has been a continuing increase from the 1980s (Fig. 1-1-33).

On the other hand, while there was sluggishness in the number of applications submitted in various European countries in the 1970s and a general continued increase in the 1980s, there has been a decrease going into the 1990s.

1.1.5.3 Ratios of Granted Patents by Japanese in Foreign Countries

For the ratios of granted patents by Japanese in foreign countries, the figure for the United States was a mere 1.5% in 1965, but there were increases year by year of up to 11.6% in 1980

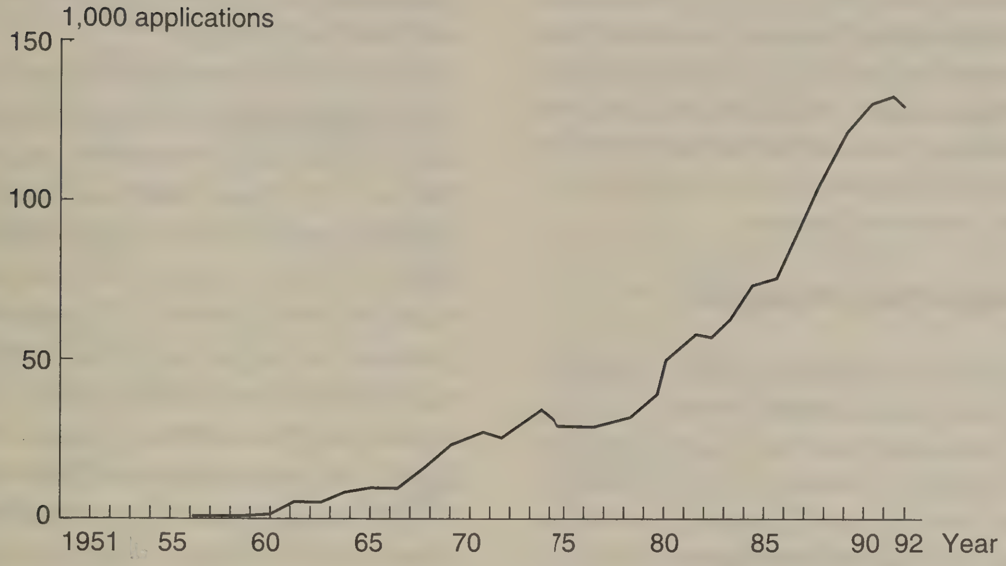


Figure 1-1-32 **Trends in the number of patent applications in foreign countries by Japanese (total number).**

Note: Number of applications include applications under the Patent Cooperation Treaty (PCT) and the European Patent Convention (EPC).
Sources: "Patent Agency Yearbook" by the Patent Agency. "Industrial Property Statistics" by the World Intellectual Property Organization (WIPO). European Patent Office statistics.

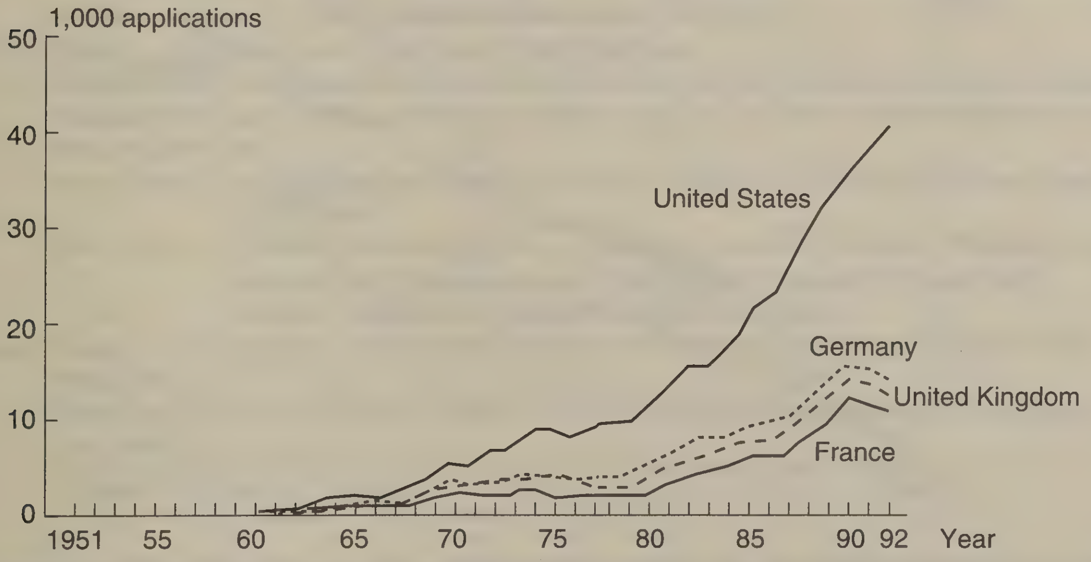


Figure 1-1-33 **Trends in the number of patent applications in selected foreign countries by Japanese.**

Notes: 1. Number of applications include applications under the Patent Cooperation Treaty (PCT) and the European Patent Convention (EPC).
2. Figures up to 1989 for Germany are for the former West Germany.
Sources: "Patent Agency Yearbook" by the Patent Agency. "Industrial Property Statistics" by the World Intellectual Property Organization (WIPO). European Patent Office statistics.

and 22.5% in 1992 (Fig. 1-1-34). There have been steady increases in share in various European countries as well, with 18.2% in Germany, 15.4% in France and 19.4% in Britain. One of the factors causing this is said to be improvements in technological capabilities, which form the basis for the creation of patents.

1.1.6 High-Tech Products

Since high-tech industries require a high degree of technological skill in their products manufacturing processes and a large amount of money invested in research for the development and production of manufactured items, the amounts of high-tech products exported can be used as indicators of one aspect of the competitiveness of industries that make use of science and technology.

For trends in market share of high-tech products export amounts by country since 1965, Japan was the lowest among selected countries in 1965 at 7.2%. Japan overtook France in 1966, however, and in 1969, overtook Britain with a share of 11.2% to rank third after the United States and West Germany. Export was sluggish thereafter in the first half of the 1970s, but Japan expanded its share starting in 1976, and by 1981 it overtook West Germany with a 17.5% share and ranked second after the United States (Fig. 1-1-35). Japan went on to overtake the United States in 1983 and since then has maintained a share that has made it number one in the world.

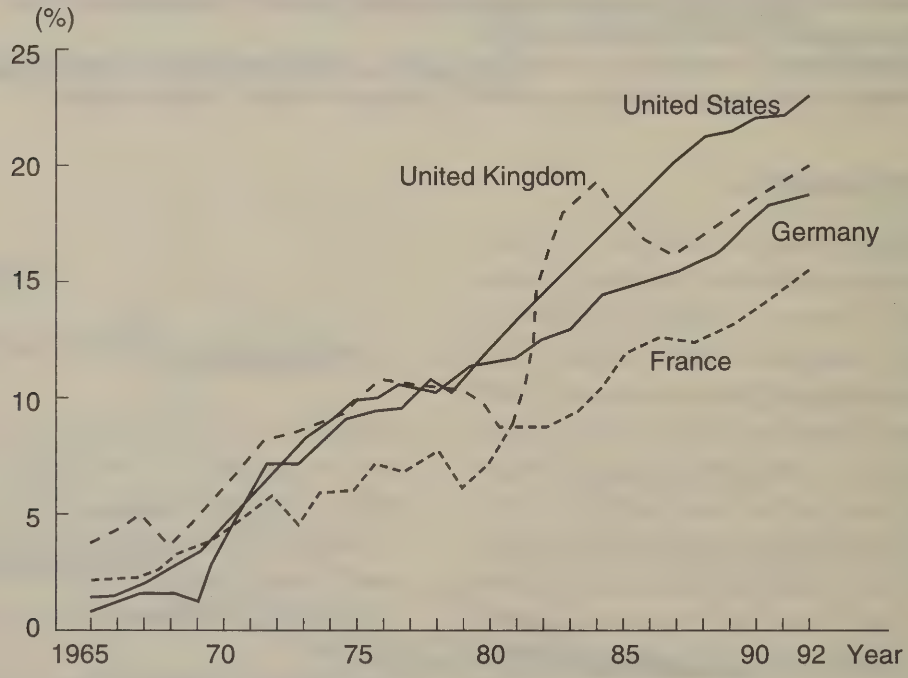


Figure 1-1-34 Trends in the ratios of granted patents held by Japanese in selected foreign countries.

Note: Figures for Germany are for the former West Germany.
Sources: "Patent Agency Yearbook" by the Patent Agency. "Industrial Property Statistics" by the World Intellectual Property Organization (WIPO).

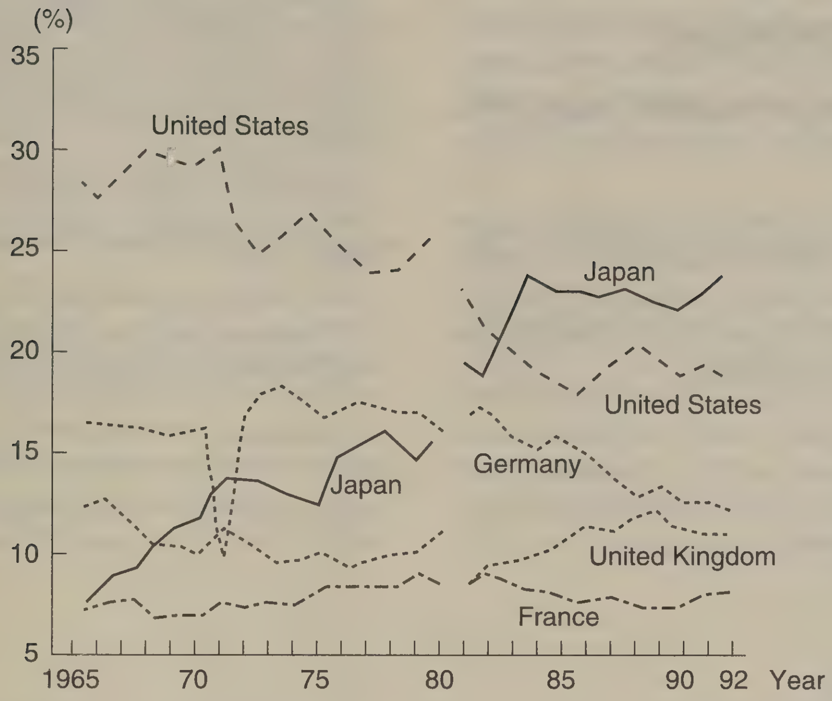


Figure 1-1-35 Export market shares for high-tech products.

Notes: 1. It should be noted that the groupings of countries used as subjects for statistical collection differed in the periods 1965 – 1980 and 1981 – 1992, but selected countries have been plotted on the same graph for both periods in order to show the trends.

2. Figures for Germany are for the former West Germany.

3. Statistical totals are plotted on the graph for the United States, Germany, France, the United Kingdom and Japan, but the following countries were also part of the statistical pools for the following periods.

1965 - 1980:	Austria, Belgium, Canada, Denmark, Italy, the Netherlands, Norway, Sweden, Switzerland
1981 - 1992:	Australia, Austria, Belgium, Luxembourg, Canada, Denmark, Finland, Greece, Iceland, Italy, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey (all OECD countries)

Sources: “Science & Engineering Indicators 1987” by the US National Science Board (for the years 1965-1980).
“Science & Engineering Indicators 1993” by the US National Science Board (for the years 1981-1992).

1.1.7 Scientific Papers

1.1.7.1 Number of Scientific Papers Published

Trends in the number of scientific papers published by various countries can be analyzed using the Science Citation Index (SCI) Database of The Institute for Scientific Information in the United States as a reference.

From 1973 to 1980, Japan's share of the number of scientific papers published was 5.2% (sixth place) in 1973 and became 6.8% (fourth place, overtaking France and West Germany) in 1980 (Fig. 1-1-36).

Japan has steadily expanded its share since 1981 and reached a share of 9.6% (second place) in 1992.

Most of the scientific papers catalogued in the SCI Database are from English-speaking countries, and thus, the actual number of Japanese

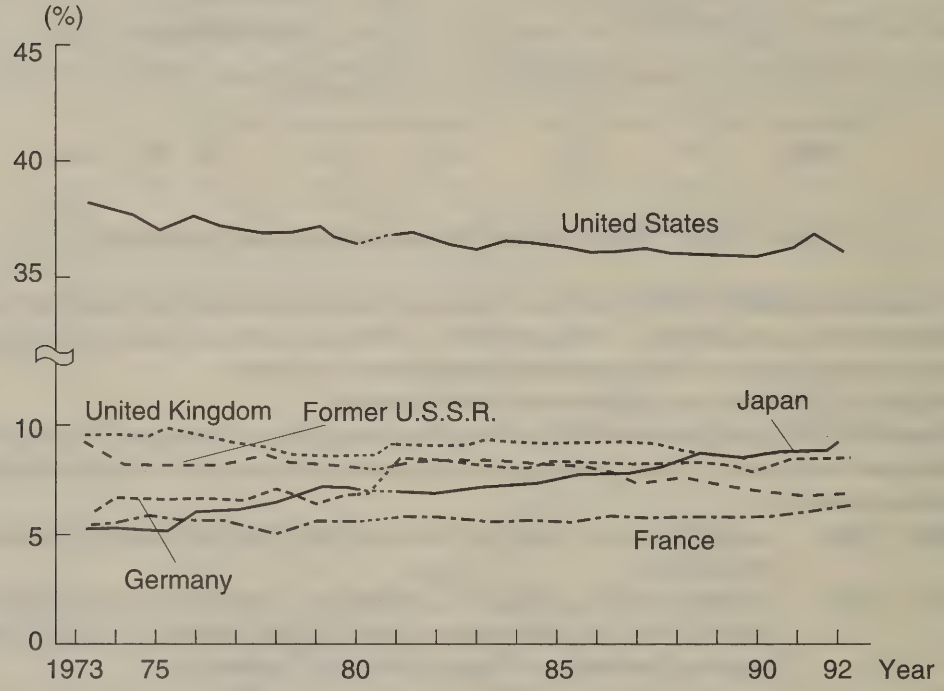


Figure 1-1-36 Trends in shares of scientific papers published by selected countries.

Notes: 1. It should be noted that although the ranges for data recorded differ for the periods 1973 - 1980 and 1981 - 1992, the data has been plotted on the same graph to show the trends.

2. Figires for Germany are for the former West Germany.

Sources: Prepared by the Science and Technology Agency on the basis of the following. "Systematic Science and Technology Indicators (Sept. 1991)," National Institute of Science and Technology Policy, Science and Technology Agency (for the period 1973-1980). "Science and Technology Indicators (1994)," National Institute of Science and Technology Policy, Science and Technology Agency (for the period 1981-1992).

Other Citation Sources: "Science & Engineering Indicators Literature Database", 1989, Computer Horizons, Inc. (for the period 1973-1980). "Science Citation Index Database", The Institute for Scientific Information (for the period 1981 - 1992).

scientific papers is thought to be underestimated. Even under these circumstances, Japan continues to expand its share of scientific papers and is second place in the world for the quantitative measurement of research results in terms of the number of scientific papers.

1.1.7.2 Number of Times Scientific Papers are Cited

The number of times scientific papers are cited is one of the qualitative indicators of research results. Japan gradually expanded its share from 3.7% (fifth place) in 1973 to 8.2% in 1992, occupying fourth place behind the United States, Britain and Germany (Fig. 1-1-37). Even though Japan publishes the second most scientific papers among all the world's countries, its fourth place rank in the world in terms of the number of citations shows that the quality of its scientific papers does not yet match their quantity.

1.1.7.3 Citation Frequency

Trends are viewed in terms of citation frequency, which is the ratio between a country's share in the number of citations of scientific papers and its share in the number of scientific papers published (with the average world index value set at 100) in order to look at the degrees of influence or the qualitative aspects of scientif-

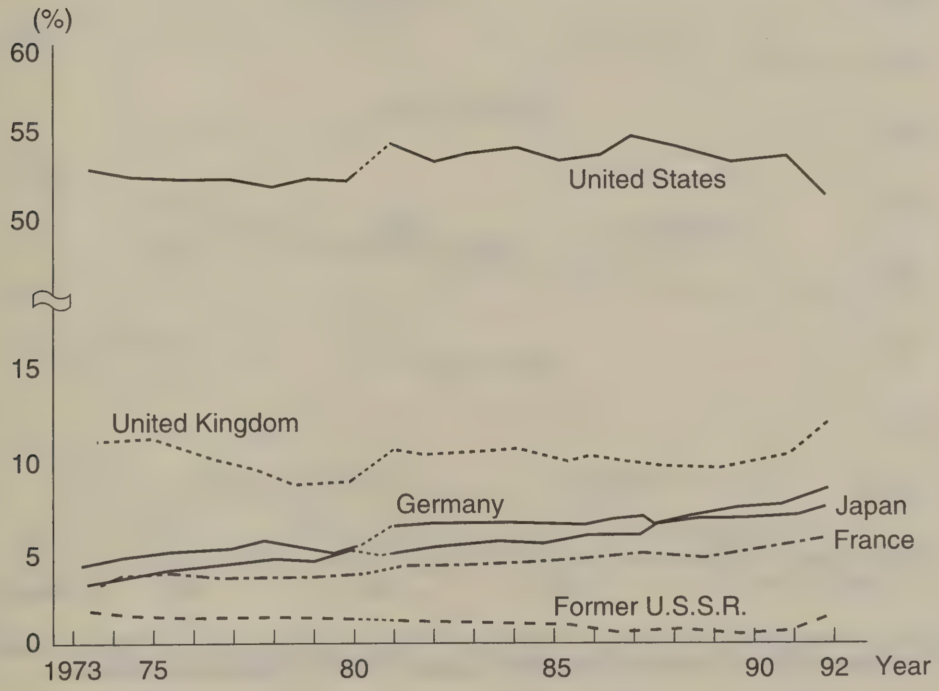


Figure 1-1-37 Trends in shares of cited scientific papers by selected countries.

Notes: 1. It should be noted that although the ranges for data recorded differ for the periods 1973 - 1980 and 1981 - 1992 the data has been plotted on the same graph to show the trends.

2. Figures for Germany through 1980 are for the former West Germany.

Sources: Same as for Fig. 1-1-36.

ic papers (Fig. 1-1-38).

The values for our country have been gradually increasing and are close to the world average value of 100, but they still fall below the average and are at the lowest level of any advance country.

It is necessary to take into consideration the bias in the SCI Database that favors English-speaking countries when analyzing this, but the number of times our country's scientific papers are cited is fewer than the number of times its scientific papers are published. Thus, the degree of influence of these scientific papers seems to fall below the average world level.

1.1.8 Nobel Prize Winners

The Nobel prizes in the natural science fields (i,e, physics, chemistry, medicine, and physiology) are considered the world's most prestigious awards, presented to researchers who have achieved internationally acclaimed results in basic science. Hence, the number of prizewinners in a given country is considered an indicator of the level of basic research in that country.

Japan's prizewinners number five in all, an extremely low number compared to the major North American and European nations. Looking at each country's share of prize winners, it is ob-

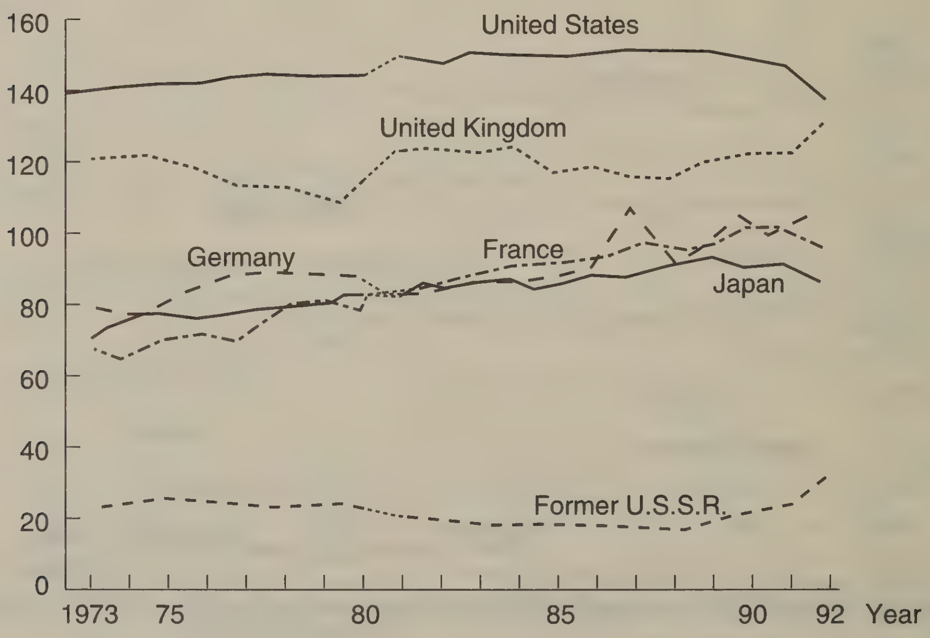


Figure 1-1-38 Trends in scientific paper citation frequency indices.

Note: Indices are for the citation frequency (with the average world index value set at 100) in terms of the ratio of a country's share of the number of citations of scientific papers to its share of the number of scientific papers published. (See Figs. 1-1-36, 1-1-37.)

Source: Same as for Fig. 1-1-36.

eserved that, in contrast to rapid rise in American prize winners following the War and the increase in Germany's prize winners since the mid-1980s, the number of Japanese prize winners has remained extremely low (Fig. 1-1-39).

1.1.9 Science and Technology Budgets

Japan's science and technology budgets of the government, whose changes reflect changes in the govenment's approach to science and technology (Fig. 1-1-40), rose throughout the 1970s at high (10% to 20%) annual rates. After dropping in the 1980s, the rate of increase has risen in recent years, reflecting a renewed awareness of the importance of promoting science and technology.

The ratios of science and technology expenditures to general account budgets generally rose from the 1950s through the 1960s, generally decreased in the 1970s and generally remained flat in the 1980s (Fig. 1-1-41). Science and technology expenditures steadily rose going into the 1990s at the same time that general account budgets were being restricted, and the ratio to the general account budget, increased from 2.90% in FY1990 to 3.51% in FY1995.

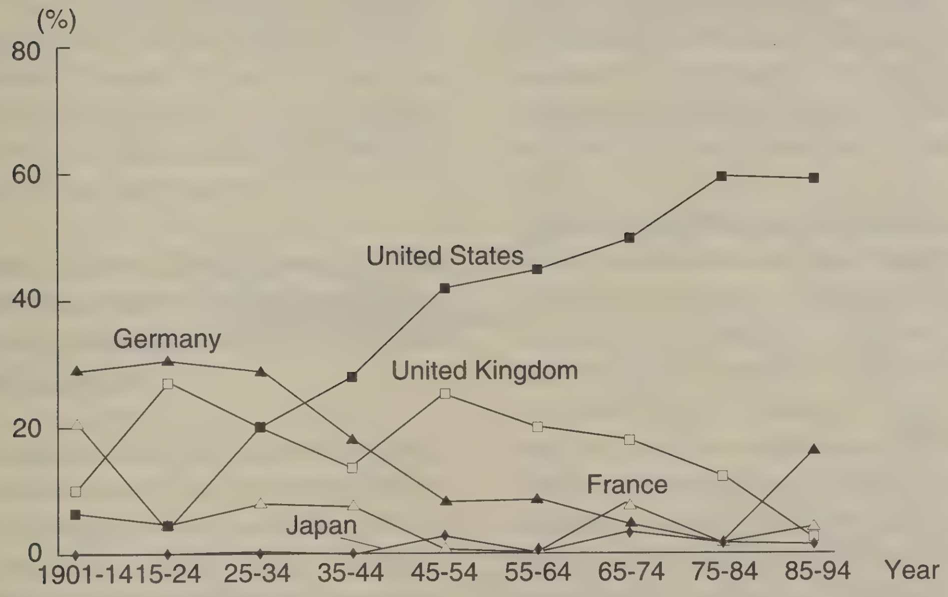


Figure 1-1-39 Changes in the share of Nobel prize winners of selected countries

Note: The above shows each country's share of the total number of prizewinners in each period.
Source: Compiled by the Science and Technology Agency from "List of Nobel Laureates 1901-1992." and others.

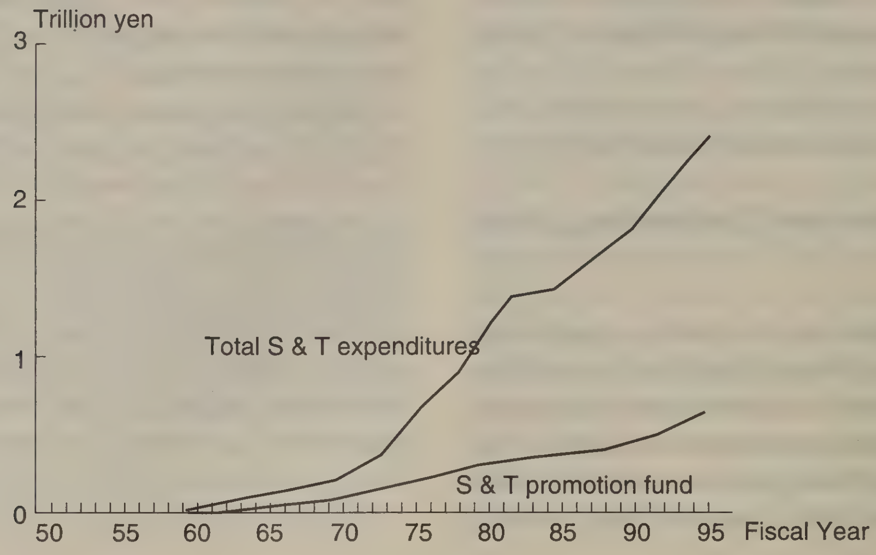


Figure 1-1-40 Trends in science and technology expenditures

Note: Figures for total science and technology expenditures are estimated by the Science and Technology Agency.

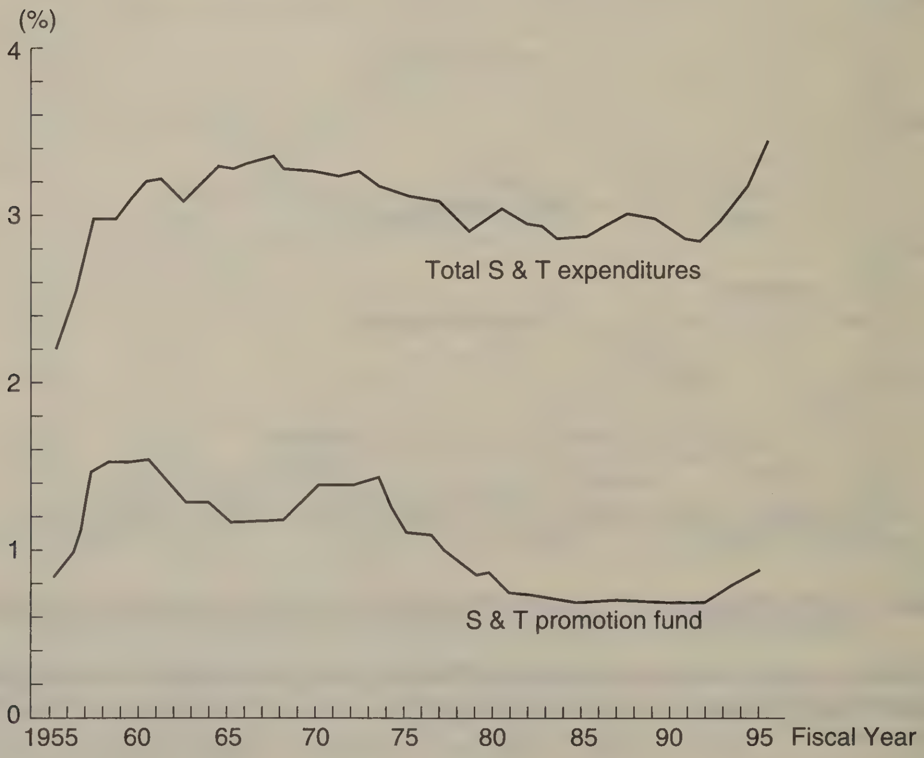


Figure 1-1-41 Trends in the ratios of science and technology expenditures as percentages of the general account budget.

Note: Figures for total science and technology expenditures are estimated by the Science and Technology Agency.

1.2 Changes in the Nation's Approach to Science and Technology

Continuing the summary in Chapter 1, Chapter 2 discusses the country's primary approach to science and technology in the four stages of postwar Japan's development (War's end through the 1950s, the 1960s, the 1970s, and the 1980s onward), and also synopsizes the factors behind the developments in each stage.

Economic and social development and scientific and technological endeavors are continuous processes and cannot be automatically periodized. From the long-range perspective, however, it appears that there are certain features that characterize various eras. On the basis of this perspective, a series of topics which indicate the approaches to science and technology in each era and illustrate the special characteristics of particular eras are presented below. When necessary, related events of other eras are referred to in the discussion of each topic to provide a better understanding of the development of science and technology.

1.2.1 From War's End through the 1950s: Science and Technology for Survival and Reconstruction and Recovery of Economy

In the early postwar years, the primary objective was survival, and so the government emphasized incresing food output and improving health and sanitation. There was also a heightened awareness of the need to promote science and technology in order to reconstruct the country and achieve economic recovery. This awareness, combined with the need to bring science and technology in Japan back up to international levels — after falling far behind the West due to the severing of relations with other countries during the War years — led to the active introduction of foreign technology. As the economy recovered, a technological innovation began to gain momentum. There was also a reorganization in academia, as the Science Council of Japan and other organizations were established under the Occupation years. During the 1950s, a time of increased awareness of the need to develop original technology, the institutional framework for promoting science and technology was laid out as the Science and Technology Agency, the Council for Science and Technology and other governmental systems were established.

1.2.1.1 Increases in Food Production

Our land had been devastated due to the Second World War and with the added number of repatriated demobilized soldiers and citizens evacuated from other countries, most people had great difficulty in finding food, clothing and shelter. The food supply was inadequate due to crop damage from cold weather, flooding, shortages of fertilizer and the general chaos immediately following the war, and the people's nutritional situation was very poor compared with what it had been before the war (Fig. 1-2-1).

The agricultural goal of our country under these conditions was to increase food production for our people. There was a pressing need to expand the area of cultivated land in the country and to increase the crop yield per unit of surface area of cultivated land. To achieve this, there was an urgent need for the development and widespread cultivation of new crop varieties, with the focus on high yields rather than on quality. Taking advantage of the development of excellent cold-resistant and high-yield varieties, rice cultivation technology made striking progress through advances in cultivation techniques using fertilizers, agricultural chemicals, plastic sheeting and other types of productive resources. The rice harvest, which was 5,820,000 tons in 1945, became a large bumper crop of 12,390,000 tons in 1955. This was partly due to favorable weather conditions. The same level of production was maintained thereafter and the rice shortage gradually

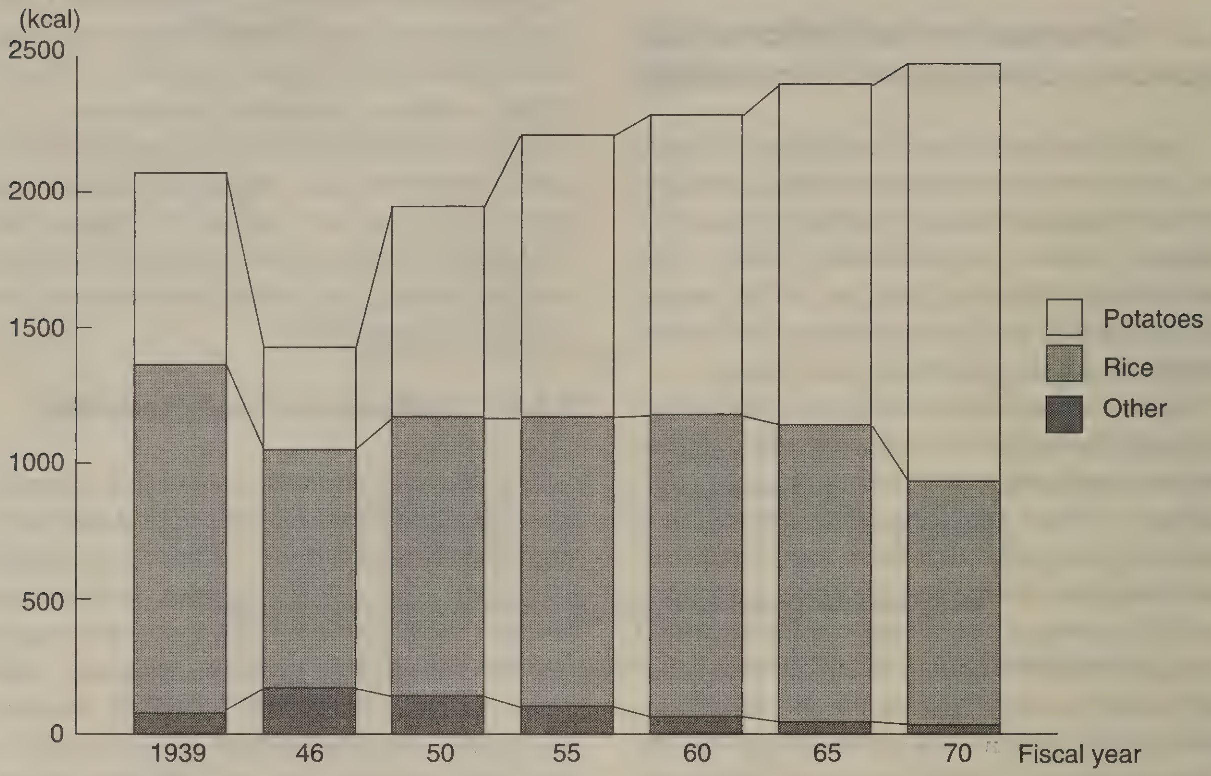


Figure 1-2-1 Nutritional energy provided per capita in Japan.

Source: "White Paper on Science and Technology (1979)," Science and Technology Agency.
Data Cited: "Food Supply and Demand Tables," and other data from the Ministry of Agriculture, Forestry and Fisheries.

dropped.

Due to the situation at the time, the Agriculture, Forestry and Fisheries Research Council was established under the Ministry of Agriculture and Forestry (now known as the Ministry of Agriculture, Forestry and Fisheries) in 1956, and administrative systems for science and technology were established in the areas of agriculture, forestry and fisheries.

Further growth in our country's manufacturing industries, including the general machinery and chemical industries, made possible the development and supply of productive agricultural resources, such as agricultural machinery, chemical fertilizers and agricultural chemicals. There were advances made in the widespread use of power cultivators and power insect control equipment, the utilization of helicopters to spread agricultural chemicals from the air and the employment of herbicides and chemical fertilizers. Agricultural productivity was greatly increased as a result, while at the same time, a surplus of labor force developed among farmers and the resulting outflow of people into secondary industries became one of the factors sustaining the high growth rates in the 1960s.

1.2.1.2 Health and Medical Care

Demobilized soldiers and other repatriated people brought contagious diseases such as typhus, smallpox and cholera, which spread widely. Diseases such as typhoid, paratyphoid and diphtheria were also spreading and dysentery was prevalent throughout the country. The people's health and well-being was at a very low level.

Japan's pharmaceutical industry was in a state of destruction and was in no position to produce vaccines necessary to counter the spread of these contagious types of diseases. The providing of vaccine by the General Headquarters of the Allied Powers (GHQ) was a great help in the period immediately following the war. Domestic production of vaccines and DDT began again during this time and progress was made in providing health and hygiene systems with the establishment of the National Institute of Health in 1947 and other such measures. DDT also played a leading role in exterminating lice and other insects that served as media for the spread of contagious types of diseases.

Efforts such as these helped to stamp out contagious types of diseases such as typhus, smallpox and cholera as Japan entered the 1950s (Fig. 1-2-2). The number of deaths due to tuberculosis, pneumonia and bronchitis, diseases which were among the major causes of death in Japan before the war, also went down (Fig. 1-2-3). This was due to improvements in the standards of living and public health, and the appearance of new pharmaceuticals such as antibiotics like penicillin, streptomycin and aureomycin, and therapeutic chemical compounds like PAS (para-aminosalicylic acid) and isoniazid. As a result of these changes, as well as advances in medical care technology, the provision of good medical facilities and the widespread application of measures to promote public health, death rates decreased markedly. The average life span, which had been 50.06 years for males and 53.96 years for females in 1947, went up to 63.60 years for males and 67.75 years for females in 1955, reaching 65.32 years for males and 70.19 years for females in 1960.

1.2.1.3 Assuring Adequate Resources

The restriction of imports as much as possible and the effective utilization of resources were regarded as indispensable to the independent development of a country such as ours, which is poor in natural resources and suffers in matters related to foreign exchange. In light of this situation, the Committee on Resources (renamed the Resources Council in 1949) was created in 1947 as an organ of the Economic Stabilization Board. The Resources Council carried out surveys on a broad range of issues concerning resources. For example, the Resources Council in 1949 recommended that our country's railways be electrified at an early date to utilize coal more effectively and rationalize railway operations by bringing down transportation costs. This led to the subsequent rapid electrification of railways in Japan. Some time later, the Resources Council also created tables of standards for ingredients regarding food, proposed a frozen food distribution chain system for perishable foods and carried on a variety of other activities in response to the needs at that time.

1.2.1.4 Economic Recovery and Independence

1.2.1.4.1 Priority Production System

The establishment of a firm foundation for Japan's economic independence was necessary for Japan to emerge from the chaotic conditions present immediately after the war. For this reason, at the end of 1946, the Priority Production System was adopted at a Cabinet meeting. In the plan for this system, natural resources, foreign exchange and other limited resources were allocated mainly to the coal and steel industries, with the idea that expansion in these two sectors would in turn lead to increased production in

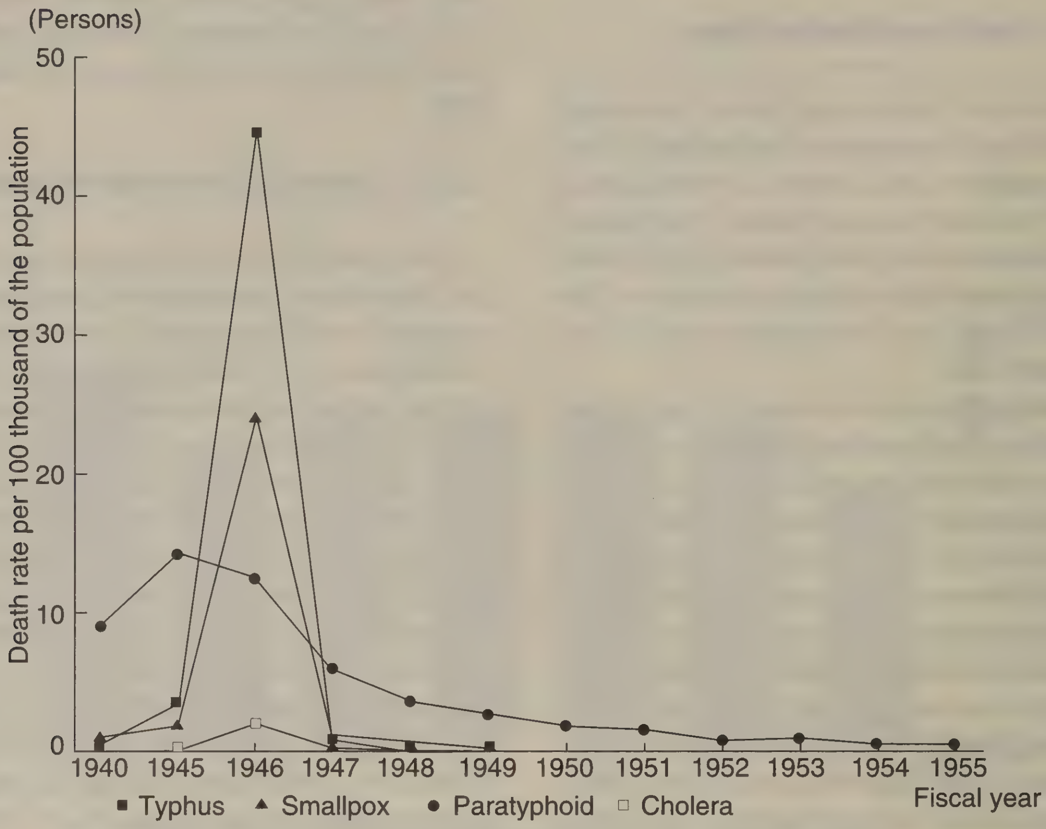


Figure 1-2-2 **Trends for selected contagious types of diseases prior to, during and following the war.**

Sources: "White Paper on Science and Technology (1979)," Science and Technology Agency.
Data Cited: "Monthly Contagious Disease Statistical Bulletin," Ministry of Health and Welfare.

other sectors.

Munitions production had ceased with the end of the war and the general machinery industry, in particular, had to switch over to the production of durable consumer goods. In 1947, the government set up a system of subsidies to offset price differentials and gave assistance to enterprises lacking international competitiveness. This system, however, was done away with in 1949 by the Dodge Plan, which had fiscal austerity as its goal. After that, enterprises in our country had no choice but to follow a course of rationalization of operations. It was also during this period that a foreign exchange rate of 360 yen to one dollar was established.

1.2.1.4.2 Lagging Behind Western Europe and the United States

Science and technology in Japan before the Second World War was centered around light industry and some industries were involved in munitions and overall science and technology was at more or less the same level as Western Europe and the United States. Cut off from foreign technology by the war and with no notable progress during this time, the level of Japan's science and technology dropped well behind that of Western Europe and the United States by

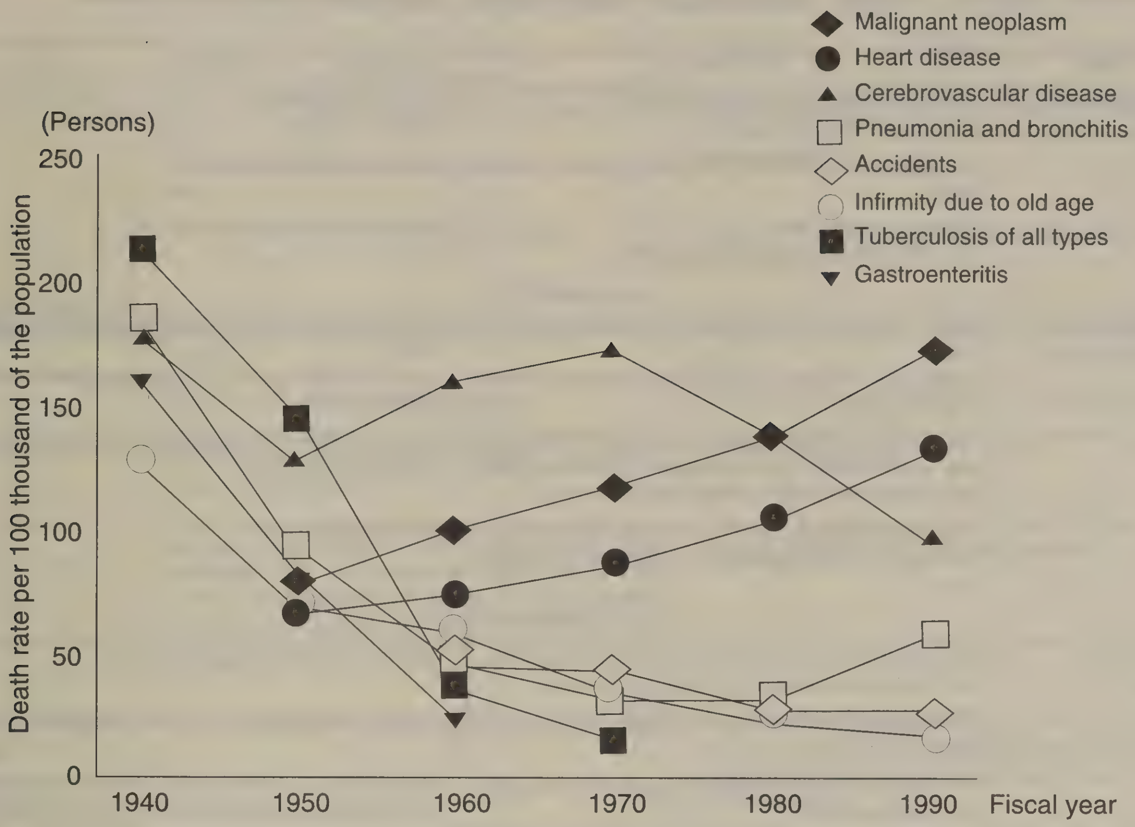


Figure 1-2-3 Changes in death rates due to major causes of death.

Note: Trends are those in what were ranked as the top five causes of death in 1940 and 1990, respectively.

Source: Prepared by the Science and Technology Agency on the basis of "Latest Demographic Statistics (1994)," Institute of Population Problems, Ministry of Health and Welfare.

the time the war ended (Table 1-2-4).

In this historical context, the Industrial Technology Agency (renamed the Agency of Industrial Science and Technology in 1952) was established in 1948. Its goals were to strengthen and move ahead with research and testing related to science and technology in industry and mining and work to improve industrial technology and to pass on their results to all industries.

The Industrial Technology Agency also was determine to rapidly raise the international level of Japanese lagging science and technology through active introduction of science and technology from the advanced countries in Western Europe and North America. At that time, however, the foreign exchange situation was unfavorable and it was extremely difficult to find a stable source of foreign currency to use to purchase such technology from abroad. Due to these conditions, the Foreign Exchange and Foreign Trade Control Laws were enacted in 1949 and the Law on Foreign Investment was established in 1950. These laws assured the provision of foreign currency to pay for designated types of technology and served as an important factor in achieving technological innovation in the industrial sectors, which were the focus of technological imports.

Table 1-2-4 Major Technological Gaps between Japan and Other World Areas

Sector	World area	Japan
Petroleum sector	• Exploratory drilling rate: 1000 m – 20 days, 2000 m – 30 days. • Refining capacity per refinery unit: 5000-10,000 barrels per day. • Boiler thermal efficiency: 80% (fluid catalyst catalytic cracking method). (United States)	• 1000 m – 50-60 days, 2000 m – 150 days. • Approximately 2000 barrels. • Boiler thermal efficiency: 60-75%.
Thermal power generation sector	• Steam pressure: 105 vapor pressure, steam temperature: 566°C. Evaporation: 400 tons/hr; average annual generator thermal efficiency: 34%. • Individual turbine-driven generators: 200,000 kW (1800 rpm), with weight reduction of 50% possible for 100,000 kW at 3600 rpm through use of high speed with hydrogen cooling. • Facilities included 20 or more AC calculating boards needed for analysis of operating conditions for complex generation systems. (United States)	• Steam pressure: 35-45 vapor pressure, steam temperature: 450°C. Evaporation: 200 tons/hr; average annual generator thermal efficiency: 24%. • Individual turbine-driven generators: 75,000 kW (1800 rpm), 30,000 kW (3600 rpm). • No AC calculating boards.
Steel and iron sector	• Iron production reaches 1700 tons per day per blast furnace, with 2000 ton blast furnaces planned. • Steel furnace capacity: average 150 t, maximum approximately 400 t. • Fuel consumption: 1 million kilocalories per 1 t of steel ingots (automatic regulator). • More than 30 high performance, high volume output strip mills (the earliest version was built in 1923). (United States)	• 1000 tons of iron per day per blast furnace. • Steel furnace capacity: average 50 t, maximum 150 t. • Fuel consumption: approximately 1.6 million kilocalories per 1 t of steel ingots (operations controlled by personal judgment). • Strip mills were first imported in 1940 – two were operating, but inadequately.
Automobile sector	• High precision mass production system established. (United States)	• Manufactured automotive performance was poor due to lags in technical levels in industries concerned. • The steel plate and sheeting used as basic material was high in tensile strength and had low ductility, resulting in problems in drawing. Plate and sheeting lacked uniformity in thickness and were apt to crack. • Engines were heavy in weight and poor in terms of fuel economy and the like.
Bicycle sector	• Automatic buffing machinery was used with plating operations and automatic equipment was used for construction, as well. • An amalgamation process using fusion was employed in frame assembly and an entire frame could be welded together in 4 min and 30 sec. • Unoxidizable Reynolds 531 tubing was developed using welding and brazing and weight was lightened to under 12 kg. • Performance improved even further with the use of chain transmissions and dynamo hubs. (United Kingdom)	• The plating operation, which comprised 23% of the entire manufacturing process, was a manual operation. • There were no improvements in or proliferation of automatic tools, such as the automatic feed press and automatic screw machine, which were used in finishing operations and which comprised 35% of total operations.

(Table 1-2-4)

Sector	World area	Japan
Shipbuilding sector	• Union melt welding (high speed automatic welding) was fully utilized. • Remarkable advances were made in automatic gas cutting devices. • Block hull construction using welding was adopted. (United States)	• Shipbuilding technology was at a fairly high level, but progress in normal technology was sluggish due to mass production of wartime shipping. • Retardation was especially striking in welding and high temperature technologies.
Machine tool sector	• There were 1,666,000 pieces of machine tool equipment (end of 1945). • Machines were replaced after 10 years of use. • Pressure-operated heat-forging machine tools were the main type and lathes comprised approximately 26.5% of cutting and polishing machine tools. • Twenty percent of lathes were automatic and assembly lines of turret lathes, multi cut lathes and other machines for mass production were set up. There was a shift toward large-scale mass production when automation began, along with the appearance of transfer machines (continuous automatic finishing machine tools). (United States)	• There were 89,000 pieces of machine tool equipment (end of 1944). • Used machine tools, 15-20 years old or more, were imported. • Cutting tools formed the vast majority of machine tools and 50.7% were center lathes. • Some lathes, such as high-speed lathes, turret lathes and screw-cutting lathes, met current world standards.
Chemical industry sector	• Ammonia production capacity quadrupled, at 1,090,000 tons. • Caustic soda (sodium hydroxide) production was 20 times that of Japan's. • The manufacture of various types of chemical products which had ammonia as their basic ingredient grew. (United States)	• There were major gaps between Japan and other world areas in equipment and production technology and industrial applications of physical sciences, with high polymer synthesis still at the germination stage. • Japan required approximately 20 times more manpower per unit of chemical industry production than the United States. • Measuring for the temperature, pressure, flow rate, concentration and the like was not improved. • The synthesis of ammonia was primarily for the purpose of manufacturing ammonium sulfate and synthetic ammonia catalysts had a life of from half a year to three years.

Note: Data taken by the Planning Bureau of the Science and Technology Agency from the "White Paper on Technology (1949)" of the Industrial Technology Agency.

Source: "White Paper on Science and Technology (1979)" by the Science and Technology Agency.

In terms of obtaining foreign exchange, the promotion of exports was seen as the major goal and the great task facing Japan at this time was to improve the quality of Japanese manufactured products. As part of this effort, the Japan Industrial Standards (JIS) system was set up under the Industrial Standardization Law in 1949. Quality control training lectures were also started by the Japan Standards Association and the Union of Japanese Scientists and Engineers (JUSE). In 1950, the Union of Japanese Scientists and Engineers invited Dr. W. Edwards Deming of the United States to Japan to give a series of lectures on quality control. In the following year, the Union of Japanese Scientists and Engineers established the Deming Prize for quality control, making all-out efforts to improve quality control in Japan.

1.2.1.4.3 The Rationalization of Business

The Korean War broke out in 1950. The supply of war material was met by Japan and Japanese industries used this opportunity to move ahead rapidly with the modernization of their own facilities and to actively carry out the introduction of foreign technology. This moved Japan into the developmental stage of the latter half of the 1950s.

Examples of the modernization of equipment and facilities were found in a variety of sectors. In the steel and iron sector, there was the introduction of continuous strip mill machinery, the installation of oxygen steel-making equipment and the creation of large-scale open hearth furnaces. In the coal sector, there was full-scale mechanization of coal extraction and the conversion from inclined shafts to vertical shafts. In the electric power sector, there was the commencement of large-scale hydroelectric power projects, such as the Sakuma Dam, and the construction of powerful new thermal power plants. In shipbuilding, there was the large-scale adoption of the block construction method and electric welding. As regards the chemical industry, there was the appearance of high polymer manufacturing and new pharmaceutical products and agricultural chemicals such as penicillin, DDT, benzene hexachloride (BHC) and the like. In the textile industry, production of new synthetic fibers such as nylon and vinylon was promoted. Due to these efforts, production levels in mining and manufacturing, which had fallen to a mere 20% of prewar levels by 1946, had already surpassed the highest prewar levels by 1950.

A system of subsidies for technological research and testing in mining and manufacturing was began in 1950, with the goal of providing assistance to private sector technological research and testing so as to promote technological development in the business. Another assistance measure taken in the area of taxation was the authorization of special tax exceptions for equipment and facilities for research and testing and for new technological equipment and facilities capable of promoting industrialization. As far as assistance in financing was concerned, the Japan Development Bank set up funding for "new technological industrialization in 1951."

1.2.1.4.4 Economic Independence and Science and Technology

The importance of science and technology came to be recognized all the more as economic recovery was going ahead at rapid pace. In 1953, the Economic Council put together its "Statement Concerning Economic Independence," in which the following goals for economic independence were set forth: 1) the establishment of normalized foreign trade, stressing the need to foster the promotion of exports; 2) improved self-sufficiency through the development of domestic resources; 3) the promotion of economic strength through the build-up of reserves. One of the four principles designed to realize these goals was through the strength then of science and technology. The building up of science and technology was regarded as necessary to increase the international competitiveness regarding exports and to plan for the steady development of domestic resources, and was also seen as playing a role in the growth of new industries and the creation of employment opportunities.

1.2.1.4.5 Technological Innovation

The Japanese economy completely recovered in ten years following the war and after its recovery embarked on an era of full-scale technological innovation, with science and technology becoming the motivating force in economic development and the efforts to improve the lifestyle of its people.

The focus of technological innovation was on heavy and chemical industries, but as a result of the comprehensive spread and large-scale development of technology, advances in technological innovation were not just limited to individual industries. This caused the growth of interrelations with other industries and brought about mutual investments leading towards modernization. This also caused a comprehensive introduction of new technology throughout all industries, leading to huge investments in equipment and facilities. The result was a general change in the appearance of Japanese industry. With rapid advances in industrialization in the heavy and chemical industry sectors, the level of technology in Japan came closer and closer to the American and West European levels.

However, this progress in technological innovation due to the all-out introduction of foreign technology and large-scale investment in equipment and facilities increased the need for innovation in business management. The Japan Productivity Center (established in 1955) served as the nucleus of the systematic introduction of American and West European business management techniques.

Japan entered a thriving economic Kan'mu period in the high tide of international economic growth that began in 1955. Influenced by the dynamic increase in demand for durable consumer goods, there were continuous good economic conditions not just in the heavy and chemical industry sectors, but for other industries, as well, with great developmental advances being made.

Key trends in major industrial sectors are as follows. In the steel and iron sector, there were increases in the size and scale of blast furnaces, the adoption of pure oxygen upward draft converters (LD converters), the conversion to large-scale, continuous and automatic rolling processes and the construction of continuous integrated iron works. In the electric power sector, there was the introduction of large-scale hydroelectric power projects, such as the Tagokura Dam, the Kurobegawa No. 4 Power Plant, the Okutadami Dam and the Miboro Dam, and the introduction of high capacity thermal power generators. In the chemical industry sector, the start of the mass production of polystyrene and polyethylene and the appearance of a petrochemical industrial complex were realized. In the synthetic fiber sector, the start of the full-scale production of nylon and vinylon and the production of acrylic and polyester fibers on a commercial scale got underway. In the general machinery sector, the export of sewing machines, cameras, watches, binoculars and other such light manufactures, as well as the establishment of mass production for and the widespread use of household electrical devices such as electric rice cookers, washing machines, electric fans, television sets and refrigerators was strenuously promoted.

In particular, large-scale improvements in the technological levels of shipbuilding and camera manufacture were occurring. By 1956, Japan led the world in the number of ships launched by its shipbuilding industry. Transistors became an integral part of people's lives with the development of transistor radios in 1955. Demand for household electrical appliances such as washing machines, refrigerators and television sets also continued to rise. Motorcycle production also was at a fairly high technological level by this time. The rapid expansion for nylon began at this time, as well, and by 1964, Japan had become the world leader in export of synthetic fibers.

In the latter half of the 1950s, the Laws for Emergency Measures for the Promotion of the Machine Industry (1956) and for Emergency Measures for the Promotion of the Electronic Industry (1957) were enacted as temporary legislation for the promotion of the general machinery and electronics industries. Through further extension in the 1960s, these laws and the Designated Electronic Industries and Designated Machine Industries Promotion Emergency Measures Law (1971) played an important role in the subsequent rationalization of these industries and the improvement in their technological levels. There was also an increasing trend in favor of independent technological development in the latter half of the 1950s. People began to realize that the closing of the technology gap with Western Europe and America was possible and wanted Japan to possess technology of its own that was not introduced from overseas. The awareness of these issues at the time can be demonstrated by the subtitle of the "White Paper on Science and Technology" for 1958: "Moving From Foreign Dependency Toward the Development of Autonomy."

There was also the recognition of the importance of technological innovation in the private sector. This brought about to a boom in the establishment of central research institutes within private businesses, which reached its peak in the early 1960s.

1.2.1.5 The Abolition of War-time Systems and the Establishment of the Science Council of Japan and the Scientific Technical Administration Committee

1.2.1.5.1 The Abolition of War-time Systems and Restrictions on Research

The Cabinet Technical Council, which had been the central agency for war-time mobilization of technical personnel, was dissolved by GHQ immediately after the war and research on such things as aircraft, radar and the isolation of radioactive isotopes could not carried out. Cyclotrons were destroyed and atomic energy research was prohibited. During this period, scientists and engineers were required to send reports to GHQ concerning their activities. The Physical and Chemical Research Institute (established as a foundation in 1917), which had held stock before the war in various companies with related interests and had used the dividends to finance research activities, was disbanded in 1948. This was in line with the GHQ policy of dissolving cartels and special semi-governmental companies. It subsequently managed to continue as the Institute for Scientific Research, which was an incorporated company. Restrictions on research were later stopped in 1952 when our country's independence was restored under the San Francisco Peace Treaty.

1.2.1.5.2 Thorough Reform of the Scientific System

During the occupation period in our country, a new system was put into place in order to facilitate advances in Japan's postwar scientific and technological activities. First of all, the Committee for Reform of Science Research Structure was established in 1947 to advise the Prime Minister. The Council's objective was to move ahead with a thorough reform of the scientific system. Based on its findings, the Science Council of Japan was inaugurated in 1949. Its objectives were to help in the peaceful recovery of our country following the consensus of scientific opinion, to contribute to the welfare of mankind as a whole and to aid in scientific progress in cooperation with the world's learned societies. The Science Council of Japan consisted of seven sections in the fields of humanistic and natural science and with approximately 210 persons who were chosen by scientists.

The Scientific Technical Administration Committee was set up as part of the Prime Minister's Office in 1949 and its objectives were to deliberate, in close cooperation with the Science Council of Japan, on policies to make administration reflect scientific and technological knowledge and to undertake necessary liaison and coordination measures in the reciprocal scientific and technological activities of various administrative bodies. The Prime Minister served as Chairman and a Cabinet Minister as vice-Chairman of this Committee, with the membership made up of knowledgeable and experienced people recommended by the Science Council of Japan and the permanent vice-ministers or vice-directors of the various ministries and agencies.

The Japan Society for the Promotion of Science was established in 1932 as an organization for the promotion of national scientific research and it has continued to promote scientific activities. It subsequently became a semi-governmental corporation in 1967, serving as the core for carrying out activities for the promotion of science.

The Basic Law of Education and the School Education Law were established in 1947 and the National School Establishment Law came into being in 1949, under which a number of new universities were set up in addition to the universities that had existed under the old educational system.

One of the great tasks confronting Japan after the war was finding ways to rapidly restore scientific exchanges with foreign countries that had been interrupted due to the war. This kind of overseas scientific exchange took place for the first time since the war in 1948, when a very small number of people involved in Japanese science and technology managed to travel overseas. In 1950, in the midst of a stringent foreign exchange situation, funds for overseas travel by scientific and technological personnel were included in the government budget and independent overseas travel by Japanese scientists and engineers was once again restarted. The Fulbright Program was started in 1951 and through it a number of capable personnel from our country studied in the United States. Subsequently, these people played major roles in the development of Japan's economy, as well as in science and technology.

Research was generally at a low point during the occupation in Japan due to insufficient research funding, a lack of proper research facilities and qualitative and quantitative inadequacies of research personnel. These tendencies were particularly evident in the private sector.

Still, even in this period of postwar confusion, the Nobel Prize for Physics was awarded for the first time to a Japanese, Professor Hideki Yukawa of Kyoto University. This was in recognition of research published by Professor Yukawa in 1934. This award showed that the basic research that had continued steadily before the war in Japan had finally gained world recognition.

1.2.1.6 Setting Up a System for the Promotion of Science and Technology

The 1950s was an era in which great weight was given to the role of science and technology in establishing economic independence and the importance of independent technological development was recognized under circumstances where there had hitherto been too much reliance on the importing of technology. It was at this time that real progress was made in the establishment of a system for the promotion of science and technology, which included an administrative organization.

1.2.1.6.1 Atomic Energy and Aviation Technology

Major developments in science and technology took place after the Peace Treaty took effect in 1952.

President Eisenhower of the United States made his speech on "Atoms for Peace," which concerned the peaceful uses of atomic energy, at a session of the United Nations General Assembly in 1953. Interest in the peaceful utilization of atomic energy gradually gained strength in Japan. The first atomic energy budget item was presented as an amendment to a bill in the Diet and was passed in 1954. At the same time, Japanese tuna fishing boats were subjected to harm from radioactive fallout from American hydrogen bomb tests and there was a sudden heightening of general concern over atomic energy. Japan was one of the participants in the First International Conference on the Peaceful Uses of Nuclear Energy held in Geneva in 1955. One of the factors that triggered this conference was a growing recognition of the necessity of setting up a research and development system for atomic energy. That same year the Atomic Energy Basic Law and the Law Establishing the Atomic Energy Commission were passed. In 1956, the Nuclear Energy Commission, which was to make decisions and plans and carry out deliberations concerning policies regarding research on and development and utilization of atomic energy, was set in motion. The Nuclear Fuel Corporation and the Japan Atomic Energy Research Institute were established at the same time. In 1957, JRR-1 (the first nuclear reactor used for research purposes) reached its critical threshold and Japan's first nuclear reactor came into being. During the same year, the National Institute of Radiological Sciences was also inaugurated. In 1963, the JPDR (an experimental power reactor) succeeded in generating our country's first nuclear power.

Aircraft production and research, which had been banned under the occupation, also became active after the Peace Treaty was enacted. The Aeronautical Technology Council was established in 1954 as part of the Prime Minister's Office and on the basis of its findings, the National Aeronautical Laboratory (the present National Aerospace Laboratory) was set up in 1955, providing a systematic framework for the promotion of research. The Aircraft Industry Promotion Law was established in 1958. This lead to the development of the YS-11 in 1962, which was our first domestically produced passenger plane.

1.2.1.6.2 Establishment of an Administrative Organization for Science and Technology

After the Peace Treaty took effect, the view that a governmental agency concerned with carrying out overall administration of science and technology should be established gained strength among the various groups concerned.

A bill to establish a Science and Technology Administrative Organization was presented by a Diet member in 1954, but was shelved. The Federation of Economic Organizations also expressed a wish for the establishment of an overall administrative body for science and technology. As a result of this series of developments, the Science and Technology Agency was set up in 1956 to carry out the overall administration of science and technology, to work for the promotion of science and technology and to contribute to economic development for the people. The Science and Technology Agency began as a grouping centering around the Atomic Energy Bureau. This Bureau had been within the Prime Minister's Office and the Secretariats of the Scientific Technical Administration Committee and the Resources Council, which had been two bodies subordinate to the Prime Minister's Office. The National Aeronautical Laboratory also was put under the Science and Technology Agency and a National Research Institute for Metals was subsequently established as a part of the agency.

The Japan Information Center of Science and Technology was established in 1957 to serve as a central body to deal with scientific and technological information in Japan, with the objective of contributing to the promotion of science and technology in Japan by swiftly and accurately providing foreign and domestic information on science and technology. The Consulting Engineer Act was also passed with the objective of establishing and developing a consulting engineer system similar to the ones existing in the United States and Western Europe. Our consulting engineer system was thus set up.

The Institute for Scientific Research, an incorporated company which had been the successor of the Physical and Chemical Research Institute (a prewar foundation), was reorganized into a special corporation in 1958 with the objectives of carrying out comprehensive scientific and technological experimentation and research and dispersing the results of these widely known.

1.2.1.6.3 Inauguration of the Council for Science and Technology

The Council for Science and Technology was established in 1959 as a means of further expediting government science and technology policies in a comprehensive manner. The Prime Minister served as Chairman of the Council, with concerned Cabinet Ministers and other knowledgeable people making up the council. Its main missions were to deliberate on such things as the establishment of basic and comprehensive policies related to science and technology, to set up long-term and comprehensive research objectives, to determine basic policy measures to move ahead with matters that were especially important for the research necessary to achieve those research objectives and to present its findings to the Prime Minister or to state their opinions when needed. The Council for Science and Technology subsequently came to play a major role in the creation of our country's policies regarding science and technology (Table 1-2-5).

The establishment of an administrative system for science and technology actively progressed in this way all through the 1950s.

Table 1-2-5 Courses Followed in Basic Policies of the Council for Science and Technology

Gist of report	Historical background	New theme	Basic recommendations
October 1960 (Report No. 1) "Concerning Ten-year Comprehensive Policy Goals for the Promotion of Science and Technology"	Plan for doubling the people's income	• Comprehensive improvement of scientific and technological levels • Shrinking the gap with advanced European countries and the U.S.	(1) Increase quantity and quality of researchers to sustain economic growth (measures to cope with the 170,000-person shortage of science and engineering students) (2) Augment data collection (3) Shift to high technology by small and medium enterprises (4) Promote acquisition of knowledge from advanced countries (5) Raise investment in research to 2% of national income
August 1966 (Presentation of 102 Problems Needing Solutions) "Opinions Concerning Comprehensive Basic Policy Measures for the Promotion of Science and Technology"	Transition to an open economic system	• 102 problems Japan should aim to solve • Provision of basic research (plans for Tsukuba Science City, research, data, etc.)	(1) Respect for originality in researchers and attention to the research environment (2) Attention to comprehensive and systematic research activity a) General areas, appearance of demarcated areas b) Increase in scale of research (3) Need for long-range planning (4) Focus on promotion of private sector research activity (5) Raise investment in research to 2.5% of national income
April 1971 (Report No. 5) "Concerning the Basis for Comprehensive Governmental Science and Technology Policies in the 1970s"	Environmental problems grew more serious	• Technology assessment • Soft science • Life science	(1) Technology assessment (2) Response to change (3) Goal-oriented research (4) Active development in environmental, soft and life science areas (5) Expansion of international cooperation (6) Raise investment in research to 2.5% of national income
May 1977 (Report No. 6) "Concerning Fundamental Comprehensive Governmental Science and Technology Policies Based on a Long-range Outlook"	Growing importance of measures to deal with energy problems	• Development of alternate energy sources • Appropriate technology (multiple systems to assure safety)	(1) Harmony between society and science and technology (2) Increase ability to respond to crises and changes (3) Comprehensive responses to growing complexities (4) Prioritized allotment of resources (5) Global and long-range perspectives (6) Raise investment in research to 2.5% of national income (3% long-range)
November 1984 (Report No. 11) "Concerning Comprehensive Basic Policies for the Promotion of Science and Technology Based on a Long-range Outlook in Response to New Situational Changes"	Increases in international frictions, the maturing of society and changes in industrial structure	• Augmenting basic research and the bases for research • Restructuring for more humanized science and technology • International standards and perspectives in research and development	(1) Harmony between science and technology and human society (2) Promotion of science and technology rich in creativity (3) Contributions to international social development (4) Raise investment in research to 3.5% of national income

1.2.1.7 Development in Universities and Other Institutions of Higher Learning

The following events characterized the developments related to universities and other institutions of higher learning in the 1950s. Japan became a member in the United Nations Educational, Scientific and Cultural Organization in 1951. In 1953, the Tokyo University Institute for Cosmic Ray Research and the Kyoto University Research Institute for Fundamental Physics were set up as research institutes attached to nationally funded universities for joint utilization by researchers from nationally funded and private universities throughout the country. In 1956, Japan's participation in the International Council of Scientific Unions' International Geophysical Year (from July 1957 through the end of 1958) took the form of sending the observation ship "Soya" out from Tokyo to establish the Showa Base on East Ongul Island and to carry out observations there in the Antarctic in 1957. Japanese rocket research, which had begun in 1955 with the first successful testing of a small rocket developed by the Tokyo University Institute of Industrial Sciences, culminated in successful observations and measurements in the upper atmosphere using rockets during this International Geophysical Year. After this, Japan went into aerospace research and development on a full-scale basis.

1.2.2 The 1960s: Science and Technology for Economic Growth and Expanding the Socioeconomic Infrastructure

In 1960 the Cabinet decided the "Plan to Double Incomes." which sought to double the size of the national economy in real term within a ten-year period beginning in FY1961. In line with this plan, the number of scientists and engineers was increased. The 1960s were also a time of technological innovation (due to the active introduction of foreign technology), an increased need for original technology to prepare for the liberalization of trade and capital, and the launching of large-scale projects in nuclear energy and space development — as well as the establishment of the institutional framework needed to promote these projects. At the same time, however, rapid expansion of the economy was causing pollution, urban overcrowding, and other problems known as the so-called strains of rapid economic growth. As a way to offset overcrowding in Tokyo, the construction of Tsukuba Science City was approved by the government.

Subsequent to the time the "Plan to Double Incomes" was decided on, the national economy developed in a way that far surpassed the goals of the original plan. By 1968, Japan's Gross National Product was second only to that of the United States in the free world. The Japanese International Exposition in Osaka in 1970 was a reflection of the high economic growth sustained in the 1960s.

1.2.2.1 The Plan to Double Incomes and Increases in Scientific and Engineering Personnel

In December 1960, the Cabinet decided on the "Plan to Double Incomes," which would attempt to double the national economy in terms of actual numerical values over a ten-year period starting with FY1961. In response to the "Plan to Double Incomes," the Council for Science and Technology issued Report No. 1: "Concerning Ten-year Comprehensive Policy Goals for the Promotion of Science and Technology." The basic approach presented in this report involved aiming for high growth in the 1960s, large-scale increases in scientific and engineering personnel and large-scale augmentation of research and development to catch up with the advanced countries of Europe and the United States.

In Report No. 1, the need to assure the quantity and improving the quality of scientists, engineers and technicians was pointed out. The Report indicated that during the ten-year period between 1960 and 1970, there would be a shortage of 170,000 college-trained scientific and engineering personnel and a shortage of 440,000 trained technical personnel graduated from technical high schools. To deal with this, it would be necessary to ensure there would be a sufficient number of college-trained scientific and engineering personnel to support this high economic growth. A plan to increase the number of students studying science and engineering was drafted by the Ministry of Education and there was an increase of 20,000 people from FY1961 to FY1963 and a further increase of 10,000 people by FY1965. In addition, the number of trained technical personnel graduating from technical high schools increased by 85,000 between FY1960 and FY1965.

This served as a foundation to support our country's to achieve high economic growth. It was thought that this course of action would benefit everyone since it would cause the economy to grow as well as increase the national income. Emphasis was put on the development of science and technology as a means to increase income and prices also came down as a result of increases in income and technological advances. During this period, black and white television sets, electric refrigerators, electric washing machines and other such durable consumer goods came into widespread use in the people's homes (Fig. 1-2-6).

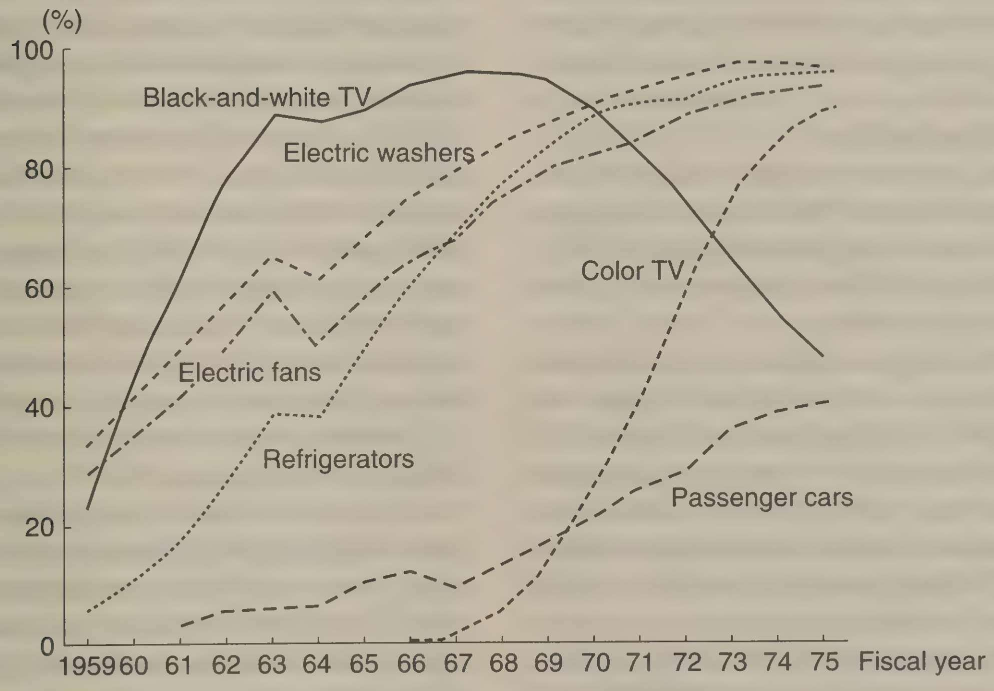


Figure 1-2-6 Trends in widespread ownership of durable consumer goods.

Source: "White Paper on the National Life Style (1991)" by the Economic Planning Agency.

1.2.2.2 Promotion of Independent Technological Development

From 1960 on, Japan's trade gradually moved toward liberalization. As a result of the international balance of payments situation in 1963, Japan joined the group of eleven countries subscribing to GATT that did not carry out restrictions on trade. As a response to a worsening in the international balance of payments in 1964, Japan joined the group of eight countries participating in the IMF that did not carry out restrictions on current transactions. Japan also joined the OECD and there was extensive liberalization of capital transactions in 1967. Through these measures, our country came more directly into contact with the world economy and it became necessary to establish what might be termed an open economic system. The strengthening of international competitiveness to face this new type of period became a matter of great concern.

With this in mind, feelings in favor of independent technological development appeared to become even stronger, and people began to want technology of their own which was not brought in from overseas.

With this situation as the background, the Research Development Corporation of Japan was set up in 1961. Its purpose was to collect data and survey the results of research and experimentation being carried out in universities as well as national research and experimentation facilities. When promising research results were found, it would then consign commercial development to businesses or other organizations in cases where development would clearly be difficult. In cases where there was relatively little risk involved and where a business could go forward with the development all on its own, the Research Development Corporation of Japan would use its good offices to support the selected company.

In the same year, the Research Associations for Mining and Manufacturing Technology Law was enacted to promote joint research by industries by establishing a system in which organizations having the status of corporations could carry out joint research and experimentation in mining and manufacturing production technology.

During this period, scientific and technological development tended to grow at a very rapid pace, shifting to high technology and becoming more integrated. Many specialized organizations were created on the basis of long-range research and development plans and there was thriving and active large-scale research and development with large amounts of funds being invested. As a part of this, the MITI National Large-Scale Project Research and Development Program was started in 1966. It began with projects concerned with the three areas: magnetohydrodynamic (MHD) power generation, ultrahigh performance computers and desulfurization technology. These were major large-scale projects in science and technology which were urgently needed and important to the national economy as a whole. By the time the program ended in 1993, numerous accomplishments had been made. For example, this program had carried out projects in 31 different areas, developed high technology, increased the use of high technology in industry and contributed to the lessen of pollution. It had also initiated a system of conditional loans for important research and development projects.

Active research and development was being carried on by private sector businesses with the goal of independent technological development. To further increase investment in research and development, the government created the tax deduction on experimental and research expense increments in 1967 as a tax policy designed to increase national expenditures on research and development and to promote research and development in the private sector. In addition, in 1968, the Japan Development Bank started a system of funding to promote independent national development of technology, which included the systems of funding for commercialization of new technology started in 1951 and funding for development of heavy machine begun in 1964.

1.2.2.3 The Advancement of Large-scale Projects

On the other hand, the development of nuclear energy, aerospace development and other such projects involving science and technology of a colossal scale, which had been started in the middle of the 1950s, became full-scale undertakings in the latter half of the 1960s when the government and private sector began working together on national projects aimed at achieving of independent technological development.

1.2.2.3.1 Aerospace Development

As regards progress in aerospace science and technology, our country was already conspicuously behind the USSR, which had succeeded in launching a satellite in 1957, and the US, which had succeeded in doing the same in 1958. As the result of concern that this lag would be regretted in the future, the Space Development Council was set up as a unit of the Prime Minister's Office. As a result of its subsequent recommendations, the Space Activities Commission was established in 1968 to plan, deliberate on and decide on important government policies concerned with aerospace development.

In the scientific research area, the Tokyo University Space Flight Research Institute (established in 1964) pursued the development of rockets and satellites, which led to the launching of Japan's first satellite (Osumi) in 1970. For practical utilization of aerospace technology, the National Space Development Agency of Japan (NASDA) was set up in 1969 as a successor to the Space Development Promotion Group (started in 1964) and other such earlier organizations. NASDA commenced the full-scale development of rockets for use in launching satellites. Institute of Space and Aeronautical Science, University of Tokyo (reorganized as the Institute of Space and Astronautical Science (ISAS)) carried out the development of scientific satellites and rockets to launch them, while NASDA developed satellites for practical utilization and rockets to launch them. Number 1 of the H-II Series of large-scale rockets, which used nationally produced technology in all its stages, was launched in 1994.

1.2.2.3.2 Nuclear Power

In 1966, the Atomic Energy Commission of Japan decided to carry out independent development of fast breeder reactors and advanced thermal reactors. The Power Reactor and Nuclear Fuel Development Corporation was established in 1967 as the main body for the carrying out of these activities. Subsequently, an advanced thermal reactors an prototype reactor (Fugen) reached the critical threshold in 1978 and in the field of fast breeder reactors an experimental reactor (Joyo) and a prototype reactor (Monju) reached critical thresholds in 1977 and 1994, respectively.

The Japan Nuclear Ship Research and Development Agency was set up in 1963, and the nuclear-powered ship Mutsu was developed. In 1974, Mutsu developed a radiation leak during testing, but was then repaired and refitted. Navigational testing was conducted on Mutsu for a year, starting from February 1991, with all desired standards being met.

During this period, the nuclear energy administrative system was reviewed and a new nuclear energy safety control system was put in place with such measures as the setting up of the Nuclear Safety Commission in 1978.

1.2.2.4 Massive Enlargement of Production Facilities

A massive enlargement of production facilities employing science and technology occurred during this time, symbolized by the "Plan to Double Incomes."

Production facility equipment grew to an even larger scale during this period, Japan's international competitiveness grew notably stronger, our industrial products assumed a major position in the world market and there was progress in the internationalization of the economy. With this sort of massive expansion in productive activity, Japan's dependence on foreign raw materials increased greatly. Steel and iron, shipbuilding, chemical, oil refining and other industries were concentrated in the Pacific Rim area because of the convenience in the sale and export of mass-produced manufactured goods. In addition, many new industrial cities arose.

The progress of the steel and iron industry was particularly striking. Through the installation of the latest technology, starting with LD converters, our country reached a world-class level in steel and iron technology. Examples of the massive enlargement of production facilities in basic industries include the construction and adoption of computerized controls in ultra-large-scale blast furnaces and LD converters and the operation of new large-scale and powerful steel plants at locations such as Mizushima, Sakai, Kimitsu, Fukuyama, Kashima and Oita.

There were advances in the enlargement in the size of ships and in increases in speed in the shipbuilding sector, and advances in increases of the capacities of thermal generation facilities in the electric power sector. Rapid increases were seen in the construction of automobile plants making only passenger cars, as well as in the scale of production in these plants. In the latter half of the 1960s there was also rapid development in Japanese automotive technology. There was road, building and bridge construction, which led to a great increase in demand for steel. This was one reason that led to the startlingly high growth of the Japanese economy. There were also notable trends toward massive enlargement outside of the industrial sector. One example was the construction of the JR Tokaido Shinkansen, which began operations just prior to the 1964 Tokyo Olympics. In the transportation sector, there was the construction of roads designed for use by automobiles only and the appearance of large capacity transport and passenger planes, such as jumbo jets and airbuses. In the communications sector, there was widespread increase in the number of telephones and progress in the automation of dialing. In the construction sector, there was the construction of major long bridges such as the Shinkansen Fujikawa Bridge and the Kanmon Bridge and the construction of major long tunnels such as the Shinkansen Rokko Tunnel and the Chuo Expressway Ena-san Tunnel and the construction of ultra-high-rise buildings.

1.2.2.5 Remedying the Strains Caused by High Growth

On the other hand, all sorts of problems (strains caused by economic growth) came forth along with rapid economic growth and became serious social issues. These included such things as various kinds of pollution and destruction of the natural environment, the clustering of the population in cities, which resulted in problems of urban overpopulation and the depopulation of rural areas, traffic accidents, the enlargement and diversity of manmade disasters such as industrial pollution, and ill effects on the health of the people and the natural environment due to food additives, drugs, agricultural chemicals and other chemical substances. A variety of measures were implemented to try to deal with these kinds of problems. The Basic Law for Environmental Pollution Control was enacted in 1967 and in 1969 special measures were enacted for the assistance and relief of people whose health was damaged by pollution. The importance of environmental science and technology was recognized and research was actively pursued to find ways to deal with outbreaks of pollution and to investigate their causes.

Interest was also growing in the promotion of interdisciplinary science and life science and the importance of appraising the impact of science and technology on things before they are applied (technology assessment) was also recognized.

1.2.2.5.1 Tsukuba Science City

The overpopulation of Tokyo became a major issue in this period and in 1962 the Council for Science and Technology made recommendations "Concerning Changes in and Enhancement of National Testing and Research Institutions." Using the aging and deterioration of research facilities in already existing national testing and research institutions as its point of departure, it proposed a concentrated shift elsewhere of national testing and research institutions located in Tokyo. This served as the major reason for the construction of Tsukuba Science City. It was determined at a Cabinet Conference in September 1963 that a city for scientific research and study at an international level should be constructed at Tsukuba. Following the acquisition of land for this purpose, construction of a large-scale earthquake-resistant experimental facility known as the National Research Center for Disaster Prevention (now known as the National Research Institute for Earth Science and Disaster Prevention), which was to be the first research facility, was started in 1968. The National Institute for Research in Inorganic Materials was the first institution to be moved from Tokyo (1972) and Tsukuba Science City came into being in FY1979.

1.2.3 The 1970s: Remedying the Strains of Rapid Growth and Responding to a Changing World

At the end of the 1960s Japan had the free world's second-largest GDP, and by the mid-1970s was spending more in total research expenditures than France and the U.k. In the 1970s emphasis shifted to science and technology for alleviating pollution and the other strains of rapid growth in the 1960s. In addition, the oil crises of 1973 and 1979 made energy a major government policy issue. The private sector, meanwhile, was redoubling its efforts to raise its level of technology in response to the newly introduced floating exchange system and other changes in international economy. This decade also saw rapid advancements in computers, semiconductors and communications, and the emergence of life science as a next-generation field of science and technology requiring the country's attention.

1.2.3.1 Measures to Deal with Pollution

Rapid economic development in Japan in the 1960s brought about a lot of pollution problems. As national health and environmental problems and other such social problems came to the front, more attention was given to science and technology as a way to counter these problems. Better appraisal of the impact of applications of science and technology on society before they were applied and plans to overcome the negative factors through pollution prevention technology were seen as indispensable to protect the people's well-being. Thus, technology grew stronger in this area.

Under these circumstances, the Council for Science and Technology proposed in its Report No. 5 (1971) that measures be taken to deal with things like environmental pollution and other strains that had arisen in this period of high economic growth. The council also proposed that science and technology be strengthened in order to serve as sources for a new generation of technological innovation in life science and other such areas. The Environment Agency was also established in 1971 and the National Pollution Research Institute (now known as the National Institute for Environmental Studies) was set up in 1974. Thus, experimentation and research on pollution prevention was further strengthened.

Regulations were strengthened to cope with worsening pollution problems caused by the high economic growth of the 1960s and there were advances in emission control technology to deal with sulfurous acid gas (SOx) and nitrogen oxides (NOx) and great increases in investment in pollution prevention equipment (Fig. 1-2-7). Controls on automobile emission gases were also strengthened, advances were made in

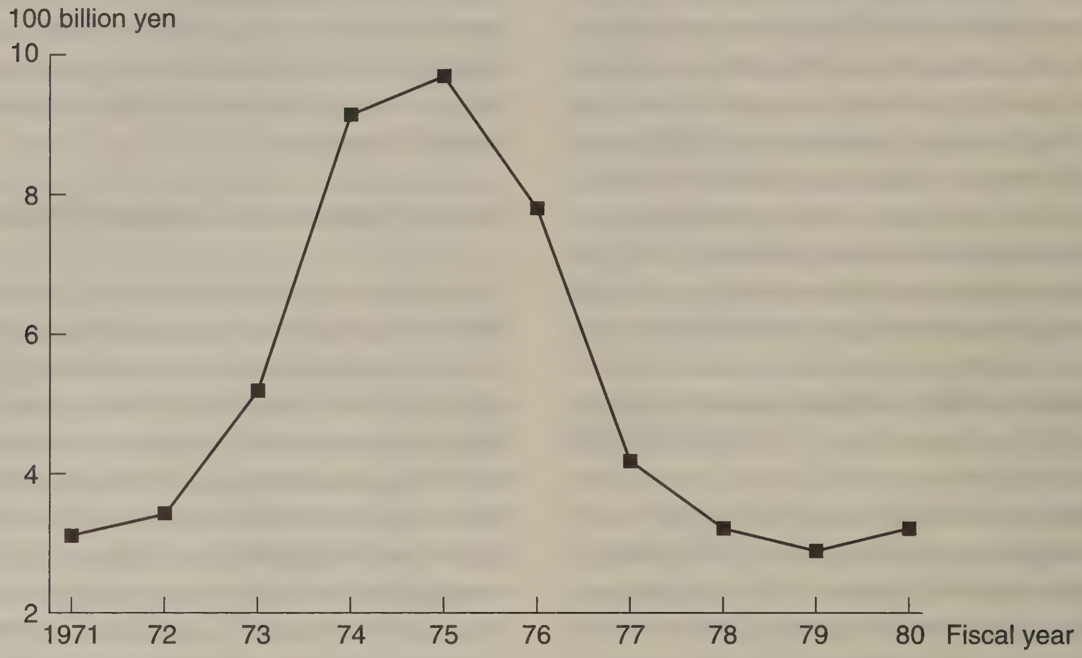


Figure 1-2-7 Amounts invested by businesses in pollution prevention.

Source: "Science and Technology Indicators (1994)" by the National Institute of Science and Technology Policy, Science and Technology Agency.

Data Cited: "Plant Investment Planning in Major Industries" by the Ministry of International Trade and Industry.

technology to deal with this and desulfurization technology research and development were being carried out as part of a large-scale industrial technology research and development system. Our country led the way in the world in dealing with these sorts of pollution problems; or perhaps we encountered these drastic problems sooner than the rest of the world did. Having no examples from abroad to serve as guidelines, we managed to deal with these problems in a relatively suitable manner through the all-out efforts of all concerned.

1.2.3.2 Responses to the Oil Crises

Responses to the energy crisis became a major policy issue as a result of the first oil crisis in 1973 and the second in 1979.

Great advances were made by Japanese industries in saving energy in response to the two oil crises. At this time, energy-saving technology was actively adopted through such things as blast furnace top pressure power generation and the like. The units of energy resources consumed per ton of crude steel were greatly reduced. In the automobile industry, as well, progress was being made in research and development aimed at increasing fuel efficiency while also dealing with pollution problems and there were large-scale improvements in Japanese automobile fuel efficiency (Fig. 1-2-8).

As a result of these circumstances, the Sun Shine Project to carry out research on and develop new energy technologies was started in 1974 and the Moonlight Project was launched in 1978 to develop energy-saving technologies. With these developments in mind, the Council for Science and Technology pointed out in its Recommendation No. 6 (1977) the need to strengthen measures in response to the sudden international changes, starting with the oil crisis of 1973, and the need to develop government policies showing concern for a better quality of life in terms of medical care, welfare and the like. Influenced by these factors, it also put strong emphasis on the development of alternate sources of energy. The Council for Science and Technology recommended a "Basic Program for Energy Research and Development" in 1978. In 1980, with the goal of reducing the Japanese economy's dependence on petroleum, legislation was enacted to promote the development and introduction of alternate energy sources in place of oil. The New Energy General Development Organization (the present New Energy and Industrial Technology Development Organization) was started to carry out the development of new energy and energy-saving technologies.

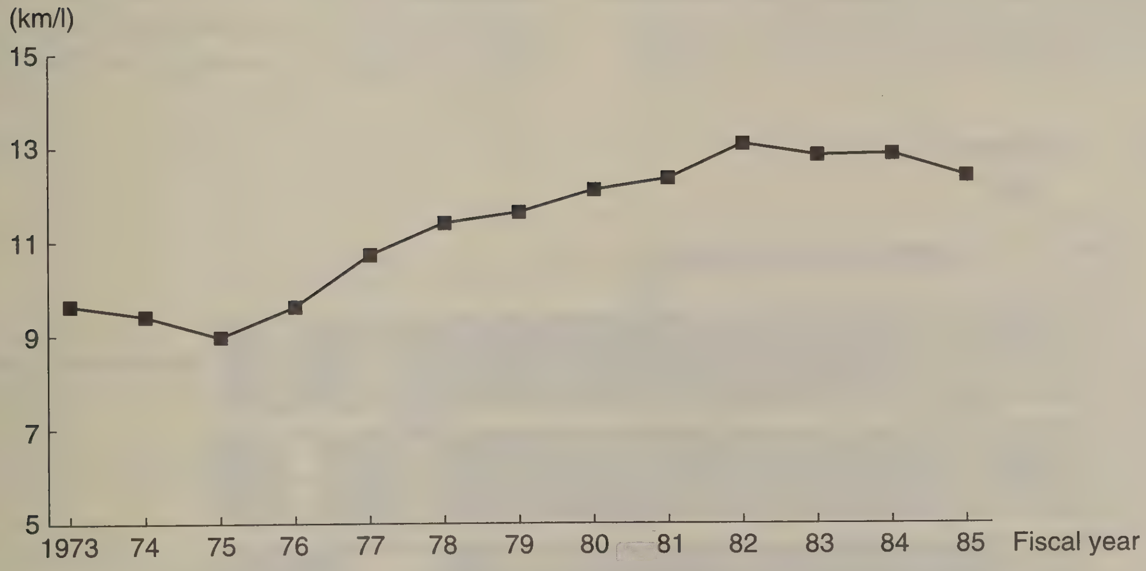


Figure 1-2-8 Trends in fuel consumption by Japanese cars.

Note: The 10-mode fuel consumption of cars produced for the domestic market.

Source: "Historical Development of Governmental Science and Technology Policies in Our Country," compiled by the National Institute of Science and Technology Policy, Science and Technology Agency, December 1989.

Data Cited: Japan Automobile Manufacturers' Association, Inc.

1.2.3.3 Business Research and Development and Changes in Technological Level

In the middle of the 1970s, Japan was overtaking France and Britain in the total amount of money spent on research and had succeeded in joining the leading countries of the world statistically. A large part of the growth was due to private sector investment in research and development. Business had redoubled its efforts to keep ahead of the times and had raised its technological level.

1.2.3.3.1 "Nixon Shock"

The Osaka International Exposition was held in 1970 under the theme "Progress and Harmony," which displayed Japan's high economic growth to the rest of the world. The 1960s were an era when our country's industries had grown and had gradually come to occupy an importance worldwide. As a result of the "Nixon Shock" at the start of the 1970s (the new American economic policy launched in August 1971), the yen was revaluated upward from a rate of 360 to US$1 to 308 to US$1 and went through a series of subsequent changes when the major countries of the world, including Japan, shifted from a fixed exchange rate system to a floating exchange rate system (Fig. 1-2-9). Japan regarded this as a crisis at the time. There was concern that business competitiveness would perish and, therefore, a stringent view was taken toward research and development in business as well.

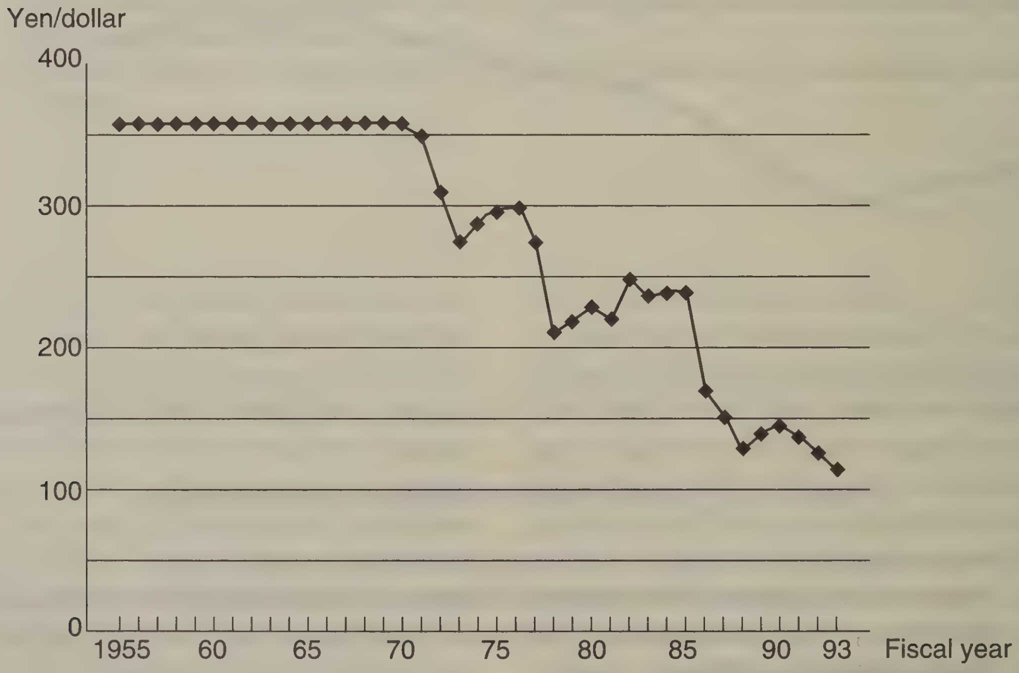


Figure 1-2-9 Trends in Yen-dollar exchange rates.

Source: "Current State of the Japanese Economy (1995)" by the Economic Planning Agency.

1.2.3.3.2 Shifts in Business Research and Development Goals as Times Change

If we look at business research and development goals in this kind of era relative to past trends in the goals of technology, we find that in the years following the war and in the 1950s, the main goals were "improvements in quality and performance" and "mass production." However, these goals diminished somewhat in relative weight in the 1960s, while the relative weight given to "preservation of the environment," "convenience and comfort," "safety," "savings in manpower" and "conserving energy" increased. The allocation of goals changed even further in the 1970s, with a great lessening of "improvements in quality and performance" and "mass production," while there were clear and rapid increases in the priorities of "preservation of the environment," "conserving energy" and "conserving resources" (Fig. 1-2-10).

1.2.3.3.3 Industrial Technology Levels

Despite great problems like the transition to a floating foreign currency exchange rate and the oil crises, this was a time when Japan's industries such as the steel and iron, automotive and home electrical appliance industries achieved leading positions in the world. According to a survey of private sector business ("Survey on Private Enterprises' Research and Development [FY1974]") conducted by the Science and Technology Agency in 1974-1975, when asked to compare Japanese science and technology with science and technology in other advanced countries of the world, more than 30% of Japanese businesses regarded Japan as being in the lead overall, while close to 60% thought that Japan was at the same level as other advanced countries. The survey also showed, however,

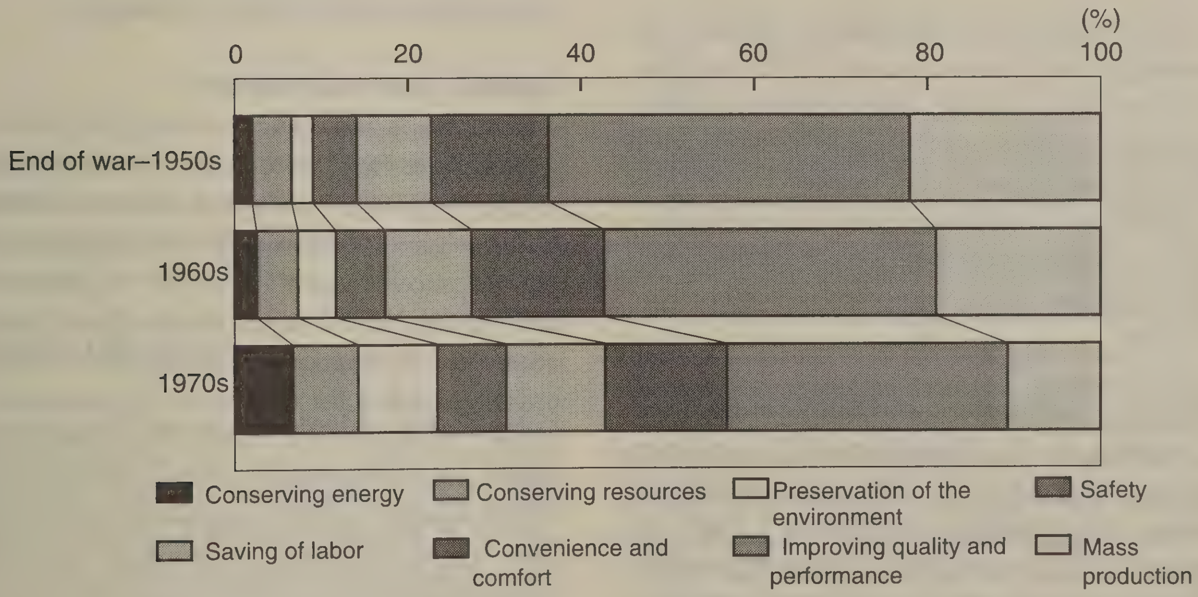


Figure 1-2-10 Changes in private sector business research and development objectives.

Source: "Survey on Private Enterprises' Research and Development (FY1979)" by the Science and Technology Agency.

that the general view was that Japan's overall technological level was comparatively lower in fields that were expected to play major roles in the next generation of technological innovations such as electronics technology, materials technology and information processing technology. Notwithstanding, as far as amounts of new contracts involving trade in technology were concerned, technology exports surpassed technology imports from 1972 onward. This may be regarded as an indication that Japan's technological level was increasing. Businesses recognized that our country had reached the technological level of other advanced countries. Yet at the same time, the importation of new technology from abroad was gradually becoming more of a problem and businesses had a growing awareness of the importance of promoting new innovative science and technology from within Japan.

1.2.3.4 Developments in Electronics

In the 1970s there was great progress in the development of electronics and in the information revolution that kept the economy moving upwards. There was notable technological progress and expansion of markets in the areas of computers, semiconductors and communications, which went on to be a basis for the development of an information-oriented society from 1980 on.

1.2.3.4.1 Computers and Semiconductors

A policy for the liberalization of computers was decided on in 1971. Fifty percent of capitalization was liberalized by 1974 and 100% liberalized by the end of 1975. A system of subsidies to promote research and development in electronic computers and related fields was made a part of the budget in 1972 and subsidies to promote research and development of very large-scale integrated circuit (VLSI) technology, basic computer technology and LSI technology was pushed forward. The contribution made as part of this effort by the VLSI Technology Group played a major role in improving semiconductor technology in Japan.

A project on "Pattern Information Processing Systems (PIPS)" was also carried out under the auspices of the MITI National Large-scale Project Research and Development Program.

The respective monetary figures for the amount of computers produced and the amount of them exported in 1970 were, respectively, 296.9 and 7.5 billion yen, while by 1980 they had grown rapidly to 1,177.6 and 168.0 billion yen, respectively. This growth continued on into the 1980s as well. Semiconductor production also increased rapidly during this period. Semiconductors, whose price had been lowered due to mass production, came to be used for industrial machinery control, the control of household electrical appliances, hand-held electronic calculators, game devices and a wide range of other industrial applications. This contributed to an increase in the competitiveness of our national manufacturing industries.

1.2.3.4.2 Communications

One issue facing our country after the war, especially from the 1950s onward, was how to satisfy the demand for communications that arose from this rapid economic growth. Major problems in public communications, in particular, had to do with the demand for telephone installation (the elimination of holdups and delays) and the demand for the ability to make dialed calls everywhere in the nation. As a result of research and development mainly carried out by NTT using microwave transmission technology, cable communications technology and the switching technology used in telephone switching devices and thanks to equipment investment that made it possible to apply the research results, holdups and delays were done away with by 1978 and instantaneous automatic telephonic communication was made available nationwide in 1979 (Fig. 1-2-11).

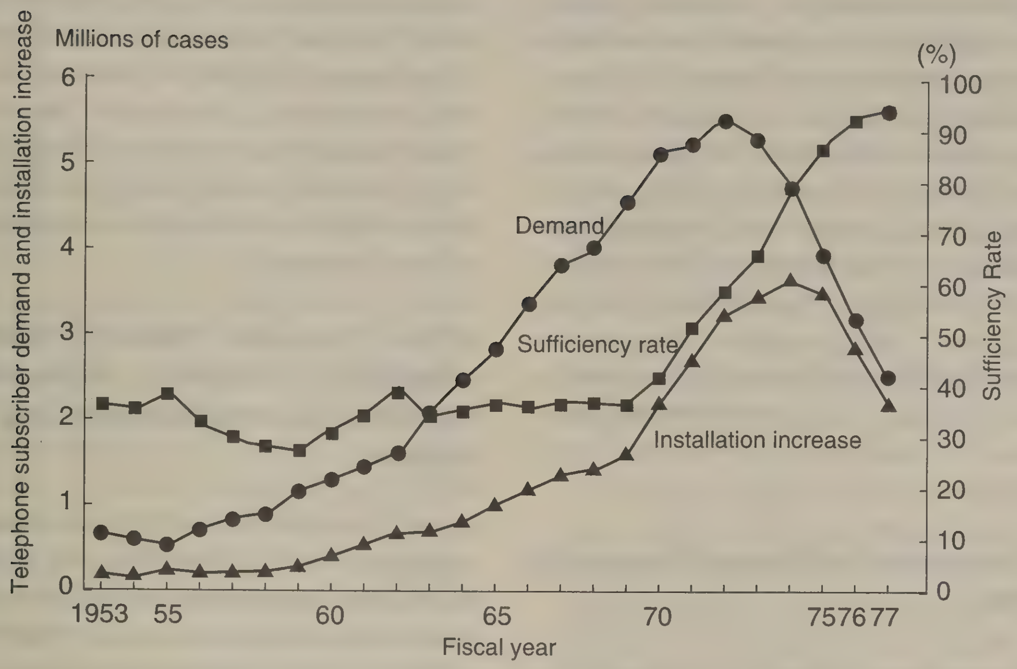


Figure 1-2-11 Trends in telephone sufficiency rates for subscribers.

Source: "Posts and Telecommunications Statistical Yearbook" by the Ministry of Posts and Telecommunications.

The demand for data communications also increased greatly during this period and car phones and other such mobile communications also were in practical use.

1.2.3.5 Life Science

Along with progress in analytical techniques due to advances in science and technology, there has been rapid development of molecular biology, which attempts to explain life and biological functions, in terms of the operations of substances consisting cells at the molecular level. Molecular biology can now account for many life phenomena and biological phenomena as the operations of substances. In addition to biological knowledge, it has also become necessary to have knowledge of physics, chemistry and other basic sciences, as well as engineering and psychology and other humanistic sciences so as to understand high-level phenomena such as perception, memory and thought in higher-order animals, including humans. Life science explains the complex and subtle mechanisms of life phenomena found in all types of organisms and is a field of science and technology which tries to apply research results to answer various questions related to human life in areas such as health and medical care, environmental protection, agricultural, forestry and fishery production, and the chemical industry. Life science has been a focus of attention in our country since the latter half of the 1960s. In its Recommendation No. 5 (1971), the Council for Science and Technology cited it as one of the fields of science and technology which should be given attention and promoted so as to achieve government policy objectives.

Plans to promote life science have been worked out in line with the recommendation and with the views expressed by the Council for Science and Technology. It was also at this time that the "Guidelines for Recombinant DNA Experiments in Universities" were determined and issued by the Ministry of Education and "Guidelines for Recombinant DNA Experiments" were determined and issued by the Prime Minister with respect to research and development in gene recombination, which had made great advances in the United States. As a result of these guidelines, plans to promote DNA research were worked out.

1.2.3.6 Measures to Advance Along with the Times

There was growing interest in marine development in such areas as the expansion of territorial waters, the scope of marine economic areas and the development of resources deep beneath the ocean. The Council for Ocean Development was established in 1971 to examine and deliberate on basic and general matters concerning marine development. The Japan Marine Science and Technology Center was started in the same year, with the objective of planning for improvements in technology related to marine development. This center, which still exists today, has been involved in projects such as the carrying out of the "Seatopia" undersea living plan and the development of the manned undersea survey vessels Shinkai 2000 and Shinkai 6500.

As a result of a debate over the possibility of the occurrence of major earthquakes in the Tokai area, the Office of Earthquake Prediction Advancement was established by the cabinet in 1976 to promote further augmentation of important measures to enhance earthquake prediction in close conjunction with concerned agencies and ministries.

A feature of the developments in universities and other institutes of higher learning at this time was set up in 1971 of National University Joint Institutes (renamed as Inter-University Research Institutes in 1989), which were independent research institutes not attached to any specific university. The first of these was the National Laboratory for High Energy Physics set up in Tsukuba Science City. In 1973, Tsukuba University was established as a university based on new concepts.

1.2.4 From the 1980s Onward: Emphasizing Creative Science and Technology and Responding to New Issues

As Japan entered the 1980s, its position in the world economy continued to rise as large trade surpluses and other factors created continuing trade surpluses and economic friction with the other principal industrialized nations. Behind Japan's rising standards of science and technology was a shifting of policy emphasis to basic research as Japan evolved from a country that introduced foreign technology into one that created original, pioneering technology. This lead to increased emphasis on creative science and technology, and in 1986 the Cabinet decided the "General Guidelines for Science and Technology Policy" to underscore the importance of and efficiently coordinate the nation's promotion of science and technology. At this time Japan became even more acutely aware of its need to play a corresponding role in science and technology in international society. Other emerging issues in this period were combating global environment problems and joining in the search for a cure for cancer. Also, private-sector investment in research and development fell in 1992 and 1993 after rising consistently throughout the previous period.

1.2.4.1 Japan's Increased Importance in the World Economy

Japan's importance in the world economy increased as it entered the 1980s. Japan's large trade surplus was the source of continued friction with other leading advanced countries on the trade and economic fronts (Fig. 1-2-12). Voluntary restraints by Japan on exports to the United States, which had begun in the 1950s, gradually shifted toward manufactured products involving a high degree of processing. The shift went from textiles, steel and iron to color television sets and voluntary restrictions on automobile and machine tool exports were added in the 1980s. There was also notable growth in Japan's semiconductor industry and U.S.-Japan friction over semiconductors grew more intense. These things could be interpreted as the results of the very high levels Japan had reached in high-tech areas. Japan had reached an era with a high level of industrial technology and had achieved leading positions in the world in steel and iron, automobiles, home electrical appliances and other products, with a focus on high-tech areas. In the balance of high-tech product trade between the United States and Japan, the United States had a continuing and consistent trade deficit from the 1980s onward, while Japan's trade surplus tended to increase continuously. At the same time, however, Japan's rapid rise in exports due to its superior industrial technology led to all sorts of economic frictions throughout the world.

1.2.4.2 Efforts to Foster Creative Science and Technology

As Japan's scientific and technological levels went up, there was a growing recognition that our country had moved from an era of importing science and technology from abroad to an era in which it led the way in these matters. As a result, government policies came to put a stronger

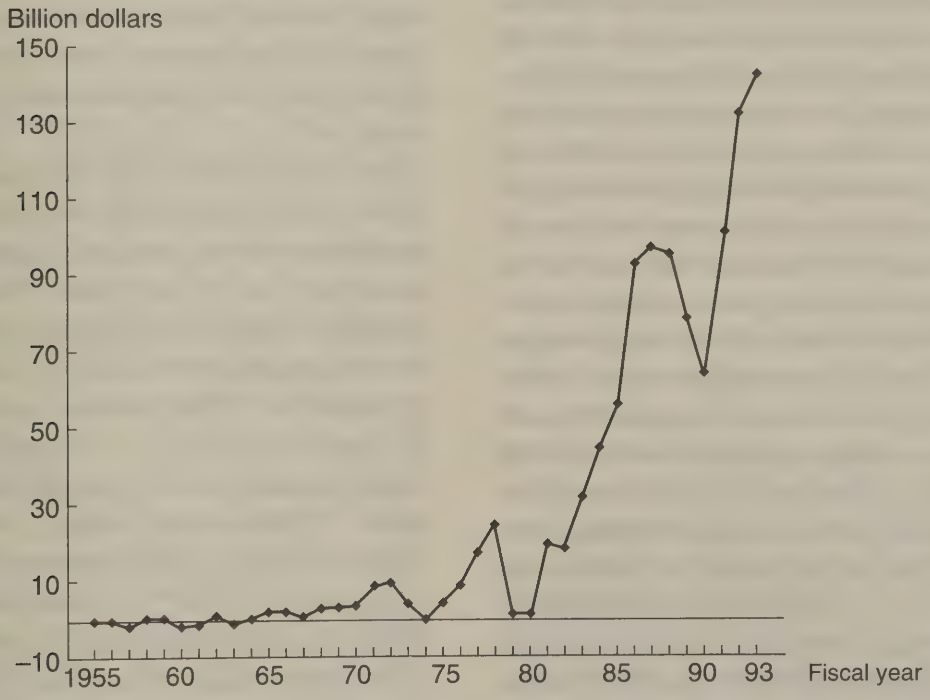


Figure 1-2-12 Japan's balance of trade.

Source: "Current State of the Japanese Economy (1995)" by the Economic Planning Agency.

emphasis on basic research.

Based on an awareness of the situation at that time, the Special Coordination Funds for Promoting Science and Technology (SCF) was appropriated in 1981 to try to increase overall coordination of science and technology policies so as to foster creative science and technology. The SCF has been managed following the guidelines of the Council for Science and Technology and has played an important role in fostering basic cutting-edge technology through coordination of the industrial, academic and governmental sectors.

It was also at this time that the Exploratory Research for Advanced Technology (ERATO) and the Research and Development Project of Basic Technologies for Future Industries were set up as new systems to foster basic research. ERATO has played an important role in promoting creative science and technology in Japan through a research system centering around groups of researchers gathered together from the industrial, academic and governmental sectors, with the top researchers selected as the project leaders. The Research and Development Project of Basic Technologies for Future Industries contributed to the idea that raising the level of basic technology is the key to the development of future industries through the organized efforts of the industrial, academic and governmental sectors working in combination. There was a heightened awareness of the importance of science and technology as keys to the solutions of a variety of socioeconomic problems and the 1982 Report of the Provisional Commission for Administrative Reform recommended strengthening the functions of the Council for Science and Technology. As a result, the Committee on Policy Matters was established in 1983 to handle important matters within the Council for Science and Technology in a timely and precise manner and to work for the development of flexible and elastic science and technology policies. Recommendation No. 11 of the Council for Science and Technology, issued in 1984, regarded the promotion of science and technology rich in creativity, the harmony between science and technology and human society and an emphasis on international aspects as basic policies for the future development of science and technology. The bases were laid out for science and technology policies over the next ten years, which aimed at the comprehensive development of science and technology to serve as the foundation of a new culture and civilization focused on the 21st century. This recommendation served as the basis for the "General Guidelines for Science and Technology Policy" decided upon by the cabinet in 1986.

There was also a strong feeling in the early 1980s that in order to promote the further development of Tsukuba City, which had been established at the end of the 1970s, an international science and technology exposition should be held there. This was realized in 1985 as the Tsukuba International Exposition of 1985 (International Science and Technology Exposition), which had the theme of "Science and Technology for Humanity, Housing and the Environment."

The Special Researcher Program was established by the Japan Society for the Promotion of Science in 1985 to assure a supply of creative researchers and to train these researchers. The National Institute Post-Doctoral Fellows Program was started by the Science and Technology Agency in 1990 to promote and stimulate basic research in Japan by assigning creative young researchers to national research institutes. The Precursory Research for Embryonic Science and Technology (PRESTO) System was also started in 1991. The developmental setups of the National Research and Development Program of MITI (Large-Scale Project), the Research and Development Project of Basic Technologies for Future Industries and other such programs were reorganized in 1993 into the Industrial Science and Technology Research and Development Program.

1.2.4.3 Determination of the "General Guidelines for Science and Technology Policy"

The General Guidelines for Science and Technology Policy were decided on by the cabinet in 1986. The need for policy guidelines determined by the cabinet to promote Japan's future scientific and technological development in a focused and efficient manner was pointed out by the 1985 Report of the Provisional Council for the Promotion of Administrative Reform. The cabinet made its determination on the basis of this, as well as on the basis of Report No. 11 of the Council for Science and Technology and a subsequent recommendation by the Council based on changes in the science and technology situation. These general guidelines set forth "the promotion of creative science and technology" as a fundamental policy and also gave full attention to "harmony between science and technology and human society" and "development of science and technology with an emphasis on their international aspects." The Council also recognized the necessity of providing a system to comprehensively advance science and technology policies based on general policy guidelines and called for the strengthening of the Council for Science and Technology and for the implementation of various other measures. It also pointed out the necessity of augmenting the power, scope, policy analysis functions and assessment functions of the Secretariat of the Council for Science and Technology and organizations such as the National Institute of Science and Technology Policy of the Science and Technology Agency were established.

In keeping with changing times, as Japan moved into the 1990s, a new comprehensive Inquiry was presented to the Council for Science and Technology in June 1990 (Inquiry No. 18) and a recommendation was compiled in January 1992. The basic concept underlying this recommendation was the contribution to be made by science and technology to benefit international society and mankind as a whole. Three goals were set forth: "coexistence of humans in harmony with the earth", "expansion of intellectual stock" and "construction of a charming society where people can live with peace of mind." Subjects such as the need to develop positive and comprehensive science and technology policies were also pointed out. In April 1992, a new version of the General Guidelines for Science and Technology Policy was decided by the Cabinet (see materials related to these guidelines in Chapter 3, Section 1 of the present document).

1.2.4.4 Promotion of Research Exchanges

1.2.4.4.1 Promotion of Research Exchanges With Other Countries

Recently, research and development have become more advanced and complex and have come to involve multiple areas of inquiry. In order to promote creative science and technology, it is now important to actively take steps to carry out exchanges of research personnel and material which transcend the frameworks of particular research organizations, and to create organizations which make such exchanges possible. These measures make efficient and effective use of the limited research resources available.

Civil service and property management systems were involved in nationally managed research, and conditions were less than ideal for the promotion of research exchanges with the private sector, foreign countries or other such entities outside the Government. As it was necessary to make legal reforms to find a way out of this situation, the Law for Facilitating Governmental Research Exchange was enacted in 1986. Since there were growing needs to make contributions to science and technology internationally and pressing demands domestically as well as from overseas for the promotion of basic and creative research, this law was amended in 1992. This further relaxed many other types of official restrictions on government research activities.

1.2.4.4.2 Promotion of Private Sector Research Activity

To promote private sector research activities, new systems of funding and other types of assistance were begun in addition to a variety of tax relief measures in the mid-1980s. The Japan Key Technology Center was established in 1985 for experimentation and research on fundamental technology related to mining, manufacturing and telecommunications. The Bio-oriented Technology Research Advancement Institution was set up in 1986 for experimentation and research in specified bio-oriented industry technology. The Adverse Drug Suffering Relief and Research Promotion Fund (the present Pharmaceutical Adverse Side Effect Relief and Research Promotion and Study Association) was started in 1987 for experimentation and research in pharmaceutical technology.

1.2.4.4.3 Promotion of Regional Science and Technology

The enhancement of regional research and development capacities was set forth as a strategic measure needed to spur regional activity in the Fourth Comprehensive National Development Plan (decided on by the cabinet in June 1987), the General Guidelines for Science and Technology Policy and elsewhere. Due to this, the number of regions aiming at advancements for the region through the promotion of high technology research and development capacity increased. Councils were set up by local governments to deliberate on policies for the promotion of science and technology, and positive steps were taken toward the advancement of science and technology. These steps included the determination of principles and guidelines for science and technology policies, the reorganization and renovation of public research institutes and the establishment of foundations to fund and promote science and technology. The Fourth Comprehensive National Development Plan included plans to develop cultural, scientific and research centers in Tsukuba and the Kyoto-Osaka-Nara Region, as well as plans to set up research cities which would be designed to make full use of the advantageous regional characteristics. Plans for advancing regional industrial development had so far focused on the building (or renovation) of factories, but recognition was given to the importance of research facilities and high-level industrial technology in addition to this as a more effective policy approach.

1.2.4.5 Development of the Information Age

Technological progress and the expansion of markets in the areas of computers, semiconductors and communications have served as the foundation supporting the development of an information-oriented society. Above all, technological innovation based on advances in semiconductor technology, brought about remarkably higher performance and lower price of computer hardware, and computers came into widespread use throughout society. Financial services and insurance businesses proceeded to go on-line, and information-oriented systems moved ahead in a broad range of industries. For example, there was the widespread use of the POS (point-of-sale information and inventory control) System in retail business. There was also the full-scale introduction of systems of CAD/CAM (computer-aided design and manufacturing) and FMS (flexible manufacturing system)in R&D, design and manufacturing. Software was also growing in importance as the use of computers expanded and became widespread. Progress was also made in the installation of networks linking computers and other information devices as these activities became widespread.

The National Information Infrastructure (NII) was proposed in 1993 as an information base covering the entire United States. It was to consist of the following four components to serve as a means for all citizens to obtain needed information at the time needed, at the place needed and at a reasonable price: 1) Thousands of telecommunications networks that are interconnected and interoperable: 2) Information devices including computer systems, televisions, and fax machines: 3) Software, information services and data services: 4) Trained personnel who construct, maintain and operate these systems. The announcement of this initiative served as the stimulus for a heightened interest in information-oriented operations in Japan, as well.

There have been startling developments recently in the proliferation of computers, in multimedia presentation of information and in other information and communications technology. The setting up of research information infrastructure became essential to develop our country's technological efforts on a world-class level. Our country's research information resource networks were extremely inadequate in terms of facilities and utilization and immediate measures to remedy this was strongly demanded. As a result, there were large-scale increases in LAN (local area networks) and computer facilities to serve as research information infrastructure in national universities and research institutes. The Research Information Improvement / Inter- Ministry Network Promotion System was established by SCF (Special Coordination Funds for Promoting Science and Technology) in 1994 and a research information network transcending the boundaries of government agencies was put into operation, linking government research institutes and universities.

1.2.4.6 Measures to Deal with Cancer

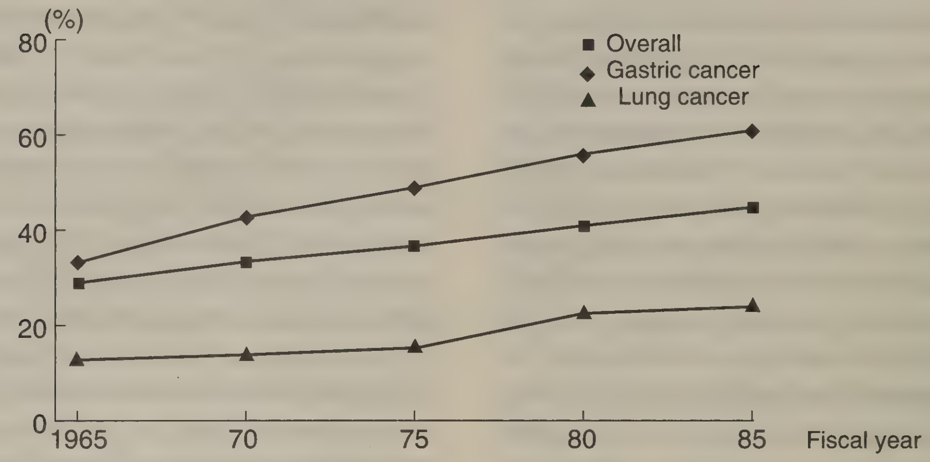
Health and medical care measures are extremely important in coping with an aging society. Science and technology have made great contributions in the area of health and medical care. As a result of improvements in the early discovery and treatment of cancer due to advances in diagnostic technology and improvements in therapeutic technology, survival rates have gradually gone up for cancer patients (Fig. 1-2-13). However, cancer still accounts for approximately 25% of the total number of deaths in our country and in order to further develop measures to deal with cancer, the entire country needs to make efforts to this end. For this reason, a "Comprehensive Ten-Year Strategy for Cancer Control" was decided on at a Cabinet meeting in 1983. In addition, the Council for Science and Technology put together a document on "Opinions Concerning Basic Policies to Advance Cancer Research." Results obtained as a consequence of the Comprehensive Ten-year Strategy for Cancer Control included the discovery of cancer genes, an understanding of the mechanism of cancer arising as a virus and the development of anti-cancer agents. It was recognized, however, that there was still a need to make advances in clinical and preventive applications with an understanding of the basic nature of cancer and the results obtained from research. Progress was to be made on the basis of the resultant "Second Term Comprehensive Ten-Year Strategy for Cancer Control" in understanding the mechanism in which cancer spreads, establishing precise diagnostic methods using genes, establishing new therapeutic methods, including Jeavy-Ion Medical Acceleratory in Chiba (HIMAC) and developing high-tech diagnostic devices incorporating advances in computer technology.

1.2.4.7 Steps Taken in the Field of International Relations in Sciece and Technology

International friction in economic areas extended to science and technology as well. During this period, there was also a greater consciousness than ever before of the role to be played in science and technology by Japan, which had succeeded in achieving a important position in the world's economy.

Revision of the 1980 U.S.-Japan Agreement on Cooperation in Research and Development in Science and Technology became a topic for discussion in the mid-1980s and talks concerning revision were conducted between Japan

(1) Males



(2) Females

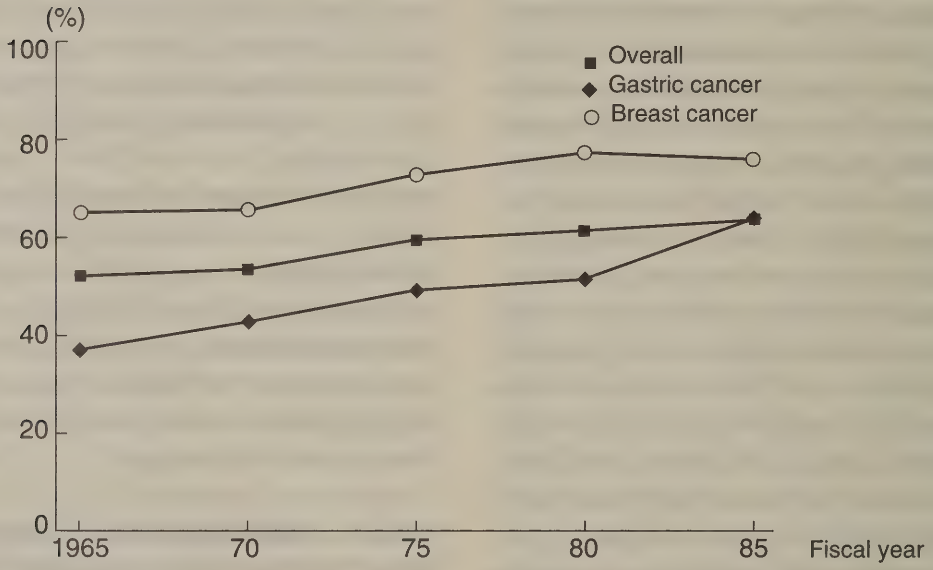


Figure 1-2-13 Trends in five-year survival rates for cancer patients.

Notes: Figures are for survival rates for periods of five years after the year (values shown on the x-axis) of initial hospitalization of patients at the National Cancer Center.
Figures are only for gastric cancer and lung cancer in males and gastric cancer and breast cancer in females. Other forms are not represented in these graphs.

Source: "Science and Technology Indicators (1994)" by the National Institute of Science and Technology Policy, Science and Technology Agency.

and the United States. A new agreement, which defined new relationships between the United States and Japan regarding science and technology, was signed in July 1988. This established a new concept of "shared responsibilities and mutual and equitable contributions and benefits, commensurate with the two nations respective scientific and technological strengths and resources." This concept was absent in previous agreements as the basic principle for developing mutual relationships in science and technology between the two countries. In addition, on the basis of discussion in its Committee for Scientific and Technological Policy (CSTP), the Organization for Economic Cooperation and Development (OECD) put together a general framework of basic principles for international scientific and technological cooperation in 1988 in the form of an OECD Council recommendation. In this document, the OECD member countries singly and jointly proposed to work toward the following goals.

①Promotion of basic research, installation of up-to-date facilities, development of cooperative projects and education and training of future scientists and engineers;

②Exchanges of researchers and expediting access by researchers to basic research facilities; and

③Expediting circulation of research results.

Japan also undertook new international activities in science and technology in response to these developments and also strengthened basic research.

To further promote the international exchange of research, the Science and Technology Agency Fellowship Program was established in 1988 to facilitate the entry of foreign researchers into government research institutes. The Special Foreign Researcher Program of the Japan Society for the Promotion of Science was established in the same year to facilitate the entry of foreign researchers into universities.

Japan proposed the Human Frontier Science Program (HFSP) at the Venice Summit in 1987. This project's goal was to make an international contribution to basic research through joint international research aimed at gaining an understanding of biological functions. An organization to carry out the program was established in France and it began operations in 1989. The Intelligent Management System (IMS) Plan was also put forward to try to develop manufacturing technology through international cooperation.

With the relaxation of tensions between East and West, the end of the Cold War following the collapse of the Soviet Union, the rapid economic growth of countries in East Asia and other such events, there is a need for new responses suited to changes in the international environment.

1.2.4.8 Heightened Concern Over Global Environmental Problems

From the second half of the 1980s into the 1990s, there was a heightened worldwide concern over global environmental problems such as the damaging of the ozone layer, global warming, acid rain and the growth of desertification. As a result, the United Nations Conference on the Environment and Development (UNCED) was held in Brazil in 1992, with about 180 countries participating. At the Conference, achievements such as the adoption of the "Rio Declaration on Environment and Development", which contains the principle for action for countries and individuals foward the 21st century and "Agenda 21," an action plan for carrying out these principles, and the securing of signatures from many nations for the United Nations Framework Convention on Climate Change, were made. An "Agenda 21 Action Plan" based upon the Rio Conference Agenda 21 was decided on by Japan at the end of 1993. This plan proposed the establishment and implementation of joint international observation, monitoring, investigation and research to protect the global environment.

The Basic Law on the Environment was enacted in November 1993, with the goal of building a society in which sustained development with minimal impact on the environment would be possible as a solution to present global environmental problems. The Basic Plan for the Environment pursuant to this law was adopted at a cabinet meeting in December 1994. This plan laid the basis for future environmental administrative action and laid out a course for the thorough investigation, research, monitoring and observation of the environment and the furtherance of technology appropriate for these tasks.

1.2.4.9 A Drop in Private Sector Investment in Research and Development

Investment in research and development by the private sector in Japan had expanded without interruption, but it decreased over the two fiscal years of 1992 and 1993 due to the effects of a protracted economic slump. In 1993, as well, a nationwide decrease in research expenditures occurred for the first time since statistical surveys of research expenditures had begun and the country faced a situation it had never experienced before. A rise in the self-appraisal of its own competitiveness also occurred. One of the reasons for this rise was the drop in our country's investment in research and development (Fig. 1-2-14).

Expansion and technology transfer into other Asian countries as Japanese businesses continued to progress, while the shift to the development and manufacture of high value-added products was not going as smoothly as one might have expected. There were also concerns about the hollowing out of industry in Japan.

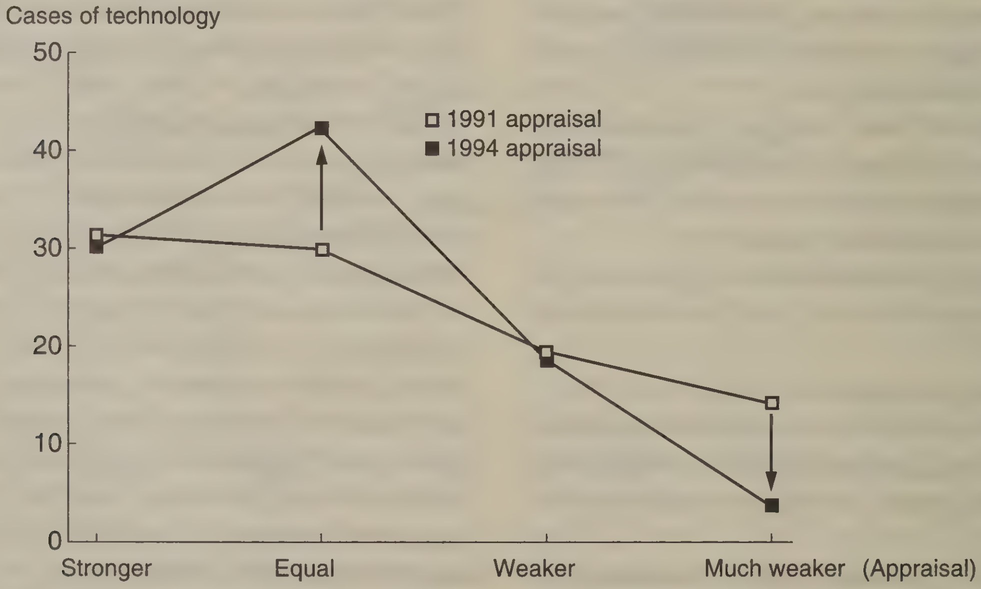


Figure 1-2-14 U.S.-Japan appraisals of critical technology levels.

Note: Based on the statistics of a report in which technological comparisons were made between the United States and Japan in 94 critical technologies, with the United States's ratings of its technology relative to Japan's case by case in four categories: 1) the United States is rated stronger than Japan: 2) the United States and Japan are rated equal: 3) the United States is rated as weaker: 4) the United States is rated as much weaker. From the perspective of the United States, the number of cases where the United States was much weaker has decreased and the number of cases rated as equal has increased.

Source: Prepared by the Science and Technology Agency from data in "Gaining New Ground," U.S. Council on Competitiveness, 1994.

1.3 Toward Science and Technology for Individual Welfare and Amenity

During the fifty years since the ending of the Second World War, Japan has worked energetically in pursuit of national prosperity.

In the "White Paper on Technology" for 1949 (compiled by the Industrial Technology Agency), technology was recognized as something that could enhance the people's standard of living. It stated that "technology in Japan in the past was used as a means to directly or indirectly strengthen the power of the military and it functions to improve the people's living environment. The most basic role of technology is to directly improve the level of consumption by the people. On the other hand, there is a correlation with demands by the people for improvements in their lives as consumers, leading to a constant stimulation of technological progress." Postwar Japan's impressive economic growth can be said to be the result of the country's pursuit of economic prosperity in the belief that this would translate into welfare and amenity in the Japanese people's lives. This material affluence notwithstanding, there are many who say they have not truly experienced this prosperity firsthand.

Chapter 3 looks at the changes in the times; defines the issues — primarily the goal of individual welfare and amenity — that should be resolved because of these changes as Japan approaches the 50th anniversary of the War's end; and discusses the proper approach to the promotion of science and technology in the coming years.

1.3.1 Issues Faced by Japan in the 50th Year since the War's End

As Japan approaches the 50th anniversary of the ending of the war, this historical period is a time when the world has witnessed the conclusion of the Cold War between East and West, which had greatly influenced global politics following the Second World War. It is also a time when mutual relationships among countries are growing closer than ever before in terms of economics and other areas. Further, it is a time when all countries are called upon to cooperate in order to deal with the existing global environmental problems.

This section will focus on an examination of the technological tasks facing Japan so as to achieve the goal of individual welfare and amenity in this time of great change.

1.3.1.1 The End of the Cold War and the Economic and Social Issues Japan Faces

1.3.1.1.1 Adapting to an Age of Mega Competition

Economic development forms the basis of a prosperous way of life. Yet, Japanese economy, science and technology are in the midst of a very trying set of circumstances.

World economies are becoming very closely linked to one another. Along with the development of Asia and the transformation of the former Soviet Union and Eastern European Bloc into market economies, it is gradually becoming more difficult for labor intensive industries and industries which do not necessarily require a high level of technology to be kept within these advanced countries. It is also believed that with the end of the Cold War it is becoming possible for the advanced European countries and the United States to assign more human and material resources to their economies. It is believed that these things will result in more stringent international competition on the economic front among the various countries in the world. In an era when the developing countries and the countries of the former Socialist Bloc are linked to one another as world markets and a society of global competition is developing, the continued maintenance of the vitality of Japanese economy is the basis of a prosperous way of life for people.

Japan's economy is now faced with maturing of her industry, catching-ups by developing and other nations, and intense competition with other industrialized nations. On the other hand, new leading industries are yet to emerge. Moreover, Japanese corporations are transferring technology to and expanding their operations in Asian countries, for instance. But because Japan has difficulty in transition to the development and production of high-value-added products, there are concerns of the hollowing out of Japanese industry and rising unemployment.

In the 50 years since the end of the War, Japan has achieved a very high degree of economic growth. Thus, it has become natural to think that since there is more prosperity now than in the past, there will be more prosperity in the future than there is now. The slowdown of the economy in recent years has stretched over a long period, however, and the people may have started to realize that the future may not necessarily be more prosperous than the present (Fig. 1-3-1). The slowdown is also thought to have been the major cause of feelings of uncertainty about the future and of limitations on future options. In addition to capital and labor, technological progress is also one of the elements affecting economic growth.

Elements cited in the 1994 "White Paper on Trade" as factors contributing to the rate of growth of the GDP (gross domestic product) were divided up statistically into the categories of capital, labor and technology (Fig. 1-3-2). It is clear from this that technology is playing a major role in contributing to economic growth. Invest-

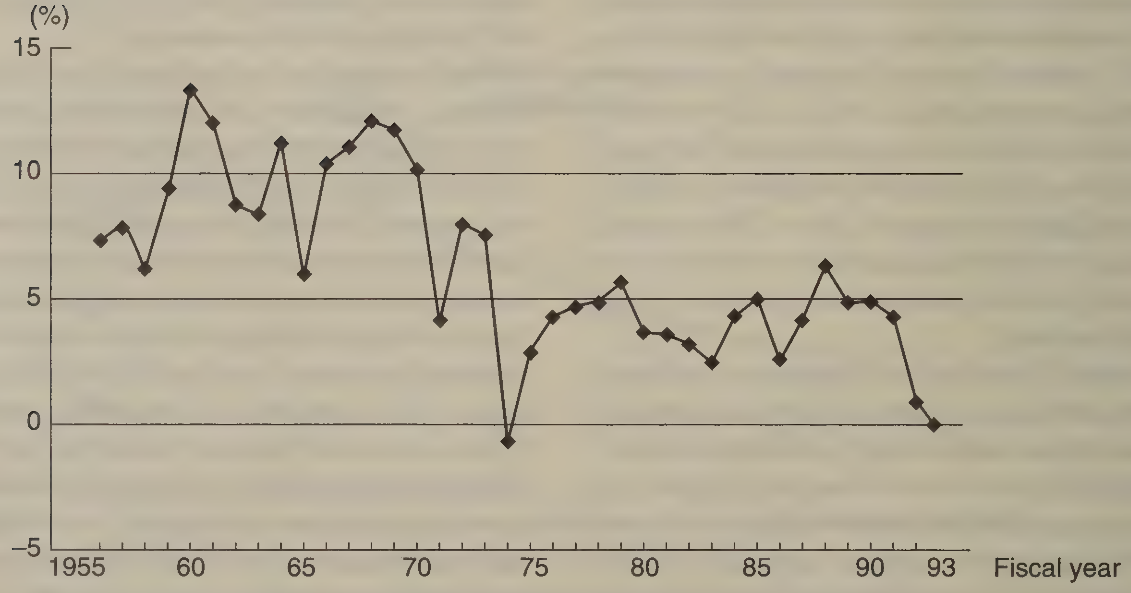


Figure 1-3-1 Rate of real Gross Domestic Product (GDP) growth.

Source: "The Current Economic Situation in Japan (1995)" by the Economic Planning Agency.

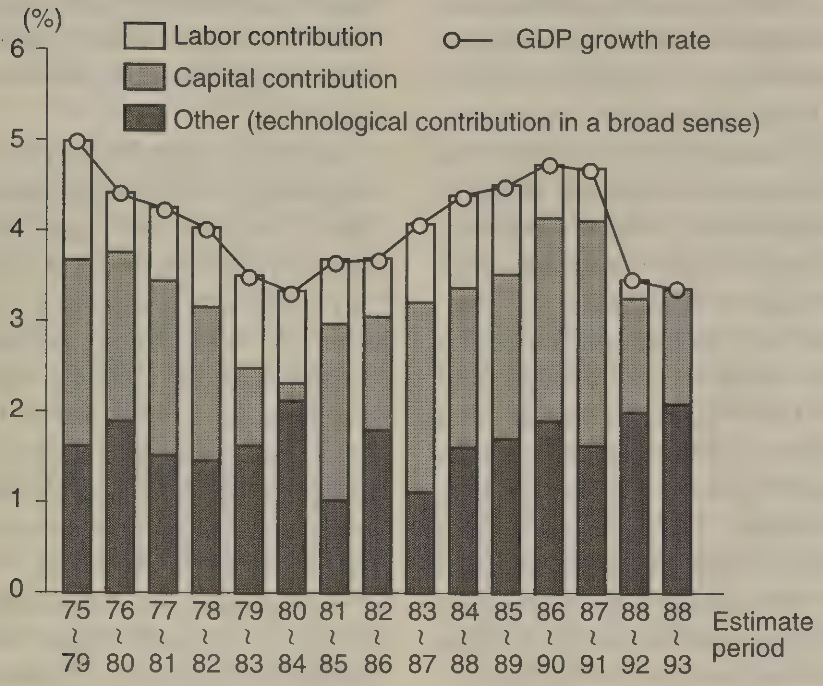


Figure 1-3-2 Analysis of contributing factors to the Gross Domestic Product (GDP) growth rate.

Remarks: The periods used for these estimates were from the first to fourth quarters of each year. In case of the 1988-1993 period, however, the period used was from the second quarter of 1988 to the first quarter of 1993.

Sources: "White Paper on International Trade Japan 1994" by the Ministry of International Trade and Industry.

Data Cited: "Labor Force Survey Report," Management and Coordination Agency. "Monthly Statistical Employment Survey," Ministry of Labor. "Annual National Economic Statistical Report," Economic Planning Agency.

ment in research and development also has a great effect on the contributions technology can make.

In the area of research and development, though, business investment in research and development, which had been increasing steadily, decreased for two successive years in FY1992 and FY1993. There was an overall decrease in investment in research and development in Japan in FY1993, in particular, and we found ourselves in a situation which we had never experienced before. Furthermore, the amount of investment in research and development in the nation overall, viewed as a percentage of GNP (gross national product), peaked in FY1990 and has been decreasing in ever since.

In view of these trends, the role that science and technology are expected to play in ensuring Japan's continued socioeconomic development is an exceedingly large one.

1.3.1.1.2 Adapting to an Age without Outside Models to Follow

In terms of Japanese economic growth in the past, Japan aimed at an early recovery from the devastation brought about by the War. During those days, the goal was to follow the ways of the advanced countries of Western Europe and the United States. Thus, Japan imported leading technology from overseas, made improvements regarding this technology in an effort to make it the nation's own and this, in turn, helped in promoting our own economic development. In this process, Japan displayed outstanding ability in such areas as "mechatronics," which was a combination of mechanical engineering and electronic control and guidance technology, the creation of intelligent devices through combining information, and electronic technology and miniaturization. However, the technology that served as the basis for products in these areas was fundamentally dependent on technology from foreign countries. Foreseeing a certain market for a product, importing basic technology from overseas and making improvements to an product already in existence came to be seen as an important means to reduce costs and improve quality. In research and development and technology development, what sustained Japanese business competitiveness was gradual improvements through making manufacturing processes more efficient, an emphasis on labor savings, the renewed application of creative ingenuity to achieve this and reductions in costs and improvements in quality derived from these measures. The savings in labor could not be expected to increase employment, but expanded production in other growth areas absorbed the excess labor force caused by these efforts to save labor.

Until now Japan has depended primarily on foreign nations for the creative activities that generate the knowledge and technology for innovative products. Japan has concentrated on steadily improving the technology introduced and on perfecting quality control. This reflects the priority given to technological improvements based on production experience over the type of intellectual and creative activities that leads to revolutionary new technologies and products.

Having caught up with other nations economically and reached the same level of other industrialized nations with respect to technology (primarily production technology). Japan has entered an age without outside models to follow, an age in which the country must find its own way.

Japan has to depend on her own capabilities in creating new knowlege and technologies. In short, from now on Japan will have to create, ahead of other nations, knowledge and technology which will lead to new products and markets. At the same time, because of developing nations that are catching up technologically, and because of the intense competition with other industrialized nations, it is now recognized that continued development will be more and more difficult unless Japan strives to develop new types of products.

New markets are created by providing products and services developed with revolutionary discoveries, and by finding new applications for existing knowlege and technologies. Thus, while efforts to acquire new, revolutionary knowledge are indispensable, finding new applications for existing knowledge and technology is also important. To encourage such activity, Japan should increase its intellectual stockpile of knowledge that is accessible to all, while also maintaining a flexible and creative way of thinking in order to apply exising knowledge and technologies to new fields. This entails efforts to expand its intellectual stockpile, an emphasis on new ideas and viewpoints, and a reassessment of the various systems that were effective in promoting science and technology when Japan was still busy catching up with advanced countries. In those days, human resources were valued for their compliance, while originality was considered constrained. From now on, however, originality should be institutionally encouraged.

1.3.1.1.3 Awareness of the World around Japan

After having achieved fifty years of stable growth during the Cold War period, Japan has become increasingly aware of its need to play an active role in international science and technology — a role commensurate with the position of economic importance it has come to occupy. Japan should also respond to a wide array of recent international developments, such as the relaxing of tensions between East and West, the end of the Cold War following the collapse of the Soviet Union, transition to market economies of the former socialist countries, and rapid economic growth in East Asia. Thus, it is now more important than ever before that Japan should assess its activities with respect to its position in a changing world.

1.3.1.2 Responding to Global Issues

Addressing the various global issues that have paralleled the world's socioeconomic development is no longer avoidable, nor affluent lifestyles can be assured any longer without resolutely responding to these issues.

Recently, there has been a growing concern in the world over global environmental problems such as global warming, depletion of the ozone layer, desertification, the loss of tropical forest areas, acid rain and the reduction in the number of animals and marine life. Damage and harmful effects resulting from global environmental problems were not limited to single countries, but went beyond national boundaries and tended to expand on a global scale. Thus, these were becoming serious problems that the whole world needed to work on the solution. As a result of heightened concern over these kinds of environmental problems, the United Nations Conference on the Environment and Development (UNCED) was held in Brazil in 1992. The "Rio Declaration" on governmental and private environmental and developmental activities going into the 21st century and "Agenda 21," an action plan for carrying out these measures, were adopted. Success was also achieved through the signing of a United Nations treaty concerning changes in the world's climate. The "Agenda 21 Action Plan" based upon the Rio Conference Agenda 21 was decided upon by Japan at the end of 1993.

Despite the importance of global environmental problems, the phenomena behind many of them are not even understood, and research on countermeasures to many of these problems has begun only recently. While data on global environmental changes are being compiled and efforts are now under way to determine their causes and understand the phenomena behind them, it is now the task of science and technology to amass the knowledge needed to evalute countermeasures to global environmental problems in a scientific manner, and so efforts to promote research should continue.

The promotion of the development of technology for more efficient utilization of energy and creation and utilization of alternative energy sources to replace petroleum is an efficient policy. At the same time, however, it is considered important to make improvements in people's way of living and economic activities based on the consumption of large quantities of resources and energy. The standardized mass production, which science and technology have maintained up until now, is leading to massive consumption and disposal problems and this may be regarded as one of the causes of environmental pollution problems. Science and technology, which controlled nature as one of its goals, have expanded regions of human habitation and in some areas is now pushing past the limits of what our world can tolerate. Global environmental problems, therefore, are not just matters involving quantitative expansion and this indicates a need for scientific and technological concepts which take the earth's needs into consideration. One of the great tasks assigned to science and technology will be to gather the data needed to work out overall decisions concerning desirable economic activities and a proper way of living from a global point of viewpoint.

The growth of the world's population is closely interrelated with global environmental problems. This is because if the world's population continues to grow — especially in developing nations — at the rapid rate now forecasted, carbon dioxide emissions will rise and other problems are likely to appear, such as shortages in resources, energy, and food. Science and technology are therefore expected to play an important role in responding to these problems, in areas such as research and development on technologies for the stable, sustainable production of food and technologies for energy conservaion and new forms of energy.

1.3.1.3 Creating an Enriching Society that Provides Peace of Mind

1.3.1.3.1 Responding to the Aging of Society

Because of lower birth rates and significantly longer life expectancies, Jpana's elderly are increasing as a percentage of the total population at a rate unparalleled in any other country. The average life expectancy in 1993 was 76.3 for males and 82.5 for females. In comparison, these were the highest levels worldwide. In 1990, 12.1% of Japan's population consisted of people 65 or older, but that percentage is expected to reach 17.0% in 2000 and 25.5% in 2020 (Fig. 1-3-3). As people live longer and longer lives, a wide array of problems — in health, medical care, and employment, for instance — are expected to arise, and comprehensive measures encompassing the related social and economic aspects and the various as-

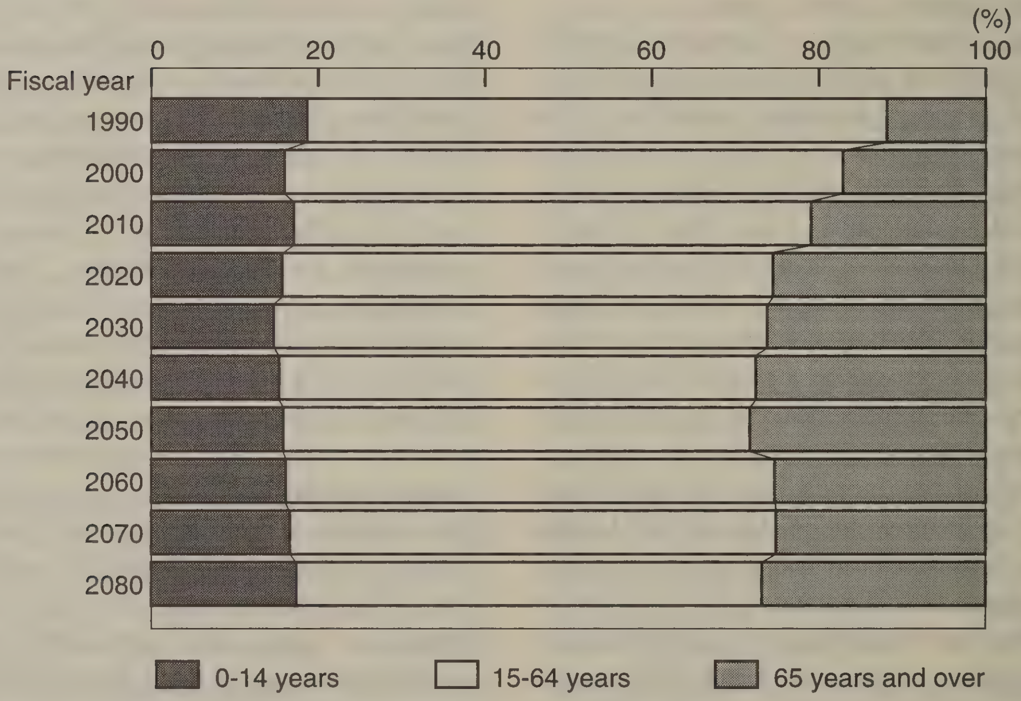


Figure 1-3-3 Aging of the Population composition in Japan.

Source: "Latest Demographic Statistics 1994" by the Institute of Population Problems, Ministry of Health and Welfare.

pects of daily life will be needed to maintain societal vitality in this new era. Here, too, science and technology are expected to make significant contributions.

1.3.1.3.2 In Search of a Society with Peace of Minds

Due to Japan's geographical and climatic conditions, natural disasters such as earthquakes, tidal waves, volcanic eruptions and damage from strong winds, heavy rain and snow occur with some frequency. People and property have sustained damage from these conditions since long ago. With changes in the socioeconomic environment in recent years involving the concentration of population and societal functions in large cities, these disasters have been becoming more complex and diverse. Various types of preventive and protective measures have been taken so far to counter these. There has been a certain degree of success in reducing damage and increasing protection, but damage due to natural disasters still present a very great problem. More than 5000 human lives and vast amounts of national assets were lost in the Great Hanshin Earthquake in early 1995.

It is important to have ongoing efforts to achieve a higher degree of disaster preparedness for the country as whole, to protect lives and property from these natural disasters, to lessen the amount of damage sustained and to devise ways of living that are less vulnerable to natural disasters. It is important to fully utilize scientific and technical knowledge in order to come up with protective and preventive measures more effective by preventing disasters before they occur, expanding protection from disasters which do occur and bringing about quick recovery after a disaster has occurred.

In our society, which is soon to be an aging one, it is also important to employ science and technology to allow people to live with peace of mind, to maintain and improve their health, to improve the environment and to assure ample societal resources.

1.3.1.3.3 The Role of Science and Technology

Until now, the pursuit of economic prosperity has driven the promotion of science and technology in the belief that scientific and technological progress would directly produce economic prosperity, which would then lead to welfare and amenity in daily life. And while maintaining economic prosperity will continue to be important, science and technology will have to do more to enable this amenity to be felt by those who, despite the currnet economic affluence, decry their current inability to feel welfare and amenity in their daily lives.

According to a "Survey on the Effects of Science and Technology on People and Society (March 1994)" carried out by the National Institute of Science and Technology Policy of the Science and Technology Agency, future expectations people have of science and technology include further developments in the economy, increases in efficiency and improvements in convenience. However, these expectations also include greater expectations concerning the solution of global environmental problems, conservation of energy and resources, improvements in safety and the substantial provisions regarding welfare (Fig. 1-3-4). These great expectations may also be viewed as reflections of dissatisfaction with current responses to these problems and great uncertainty about the future. The solving of this dissatisfaction and discontent may be a precondition for any real feeling of prosperity.

1.3.1.4 The Public's Faith in Science and Technology

The public's faith in science and technology has been greatly shaken by the collapse of modern architectural structures during the Great Hansin/Awaji Earthquake. There have also been incidents in which the public's safety has been compromised by the use of scientific and technological knowledge in manners contrary

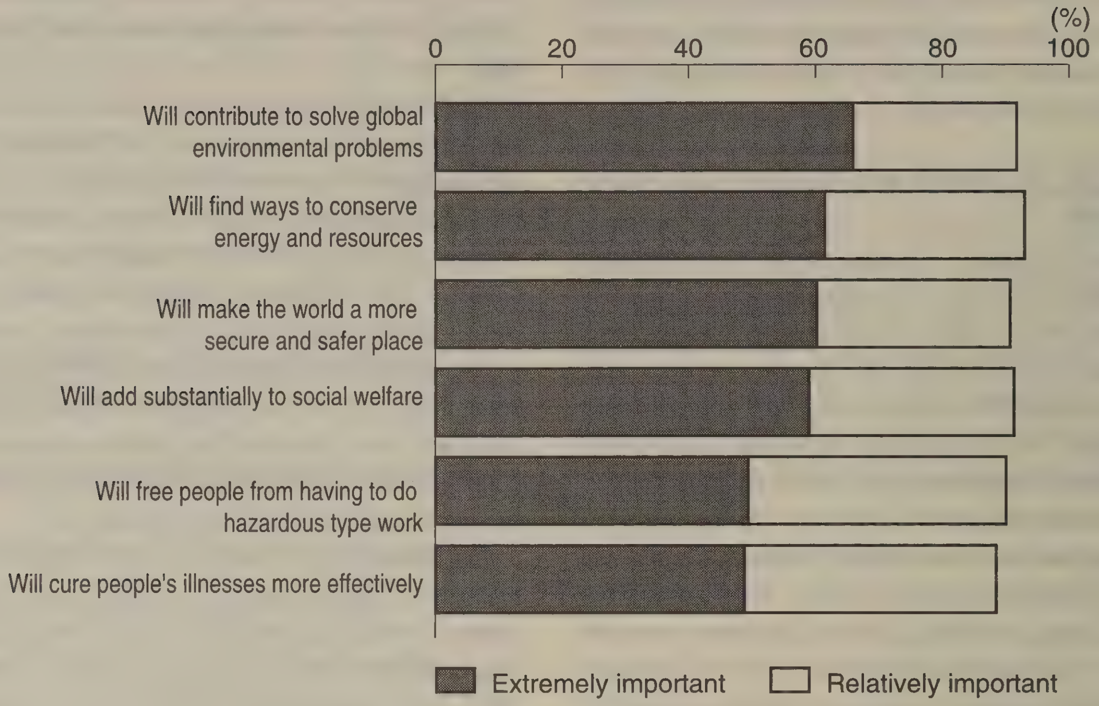


Figure 1-3-4 Expectations of science and technology.

Source: "Survey of the Influence of Science and Technology on People and Society," National Institute of Science and Technology Policy of the Science and Technology Agency, March 1994.

to its original objective of economic development and improving people's lives.

Society will accept and support science and technology if faith in it is established and its contributions are widely understood. Nevertheless, the important role of science and technology in achieving today's material affluence notwithstanding, the Japanese public is less inclined than those in the West to trust in and positively assess scientific and technological progress. (Fig. 1-3-5)

In view of these realities, it is now important to maintain and enhance the public's faith in science and technology by addressing the factors believed to affect their faith therein and their assessment thereof.

In the next section of this document, an analysis of desirable approaches to the future advancement of science and technology will be shown while keeping these issues in mind.

1.3.2 Striving to Become a Nation based on Creative Science and Technology

Japan's postwar development is the result of persistent, diligent efforts and the application of the capabilities of the Japanese people, the most important resource in a country bereft of natural resources. This most valuable resource will have to be drawn on even further in order for Japan to continue her development through the 21st centry. This, in turn, requires that Japan should become a nation that bases its foundation on creative science and technology. In short, Japan should be a nation that makes

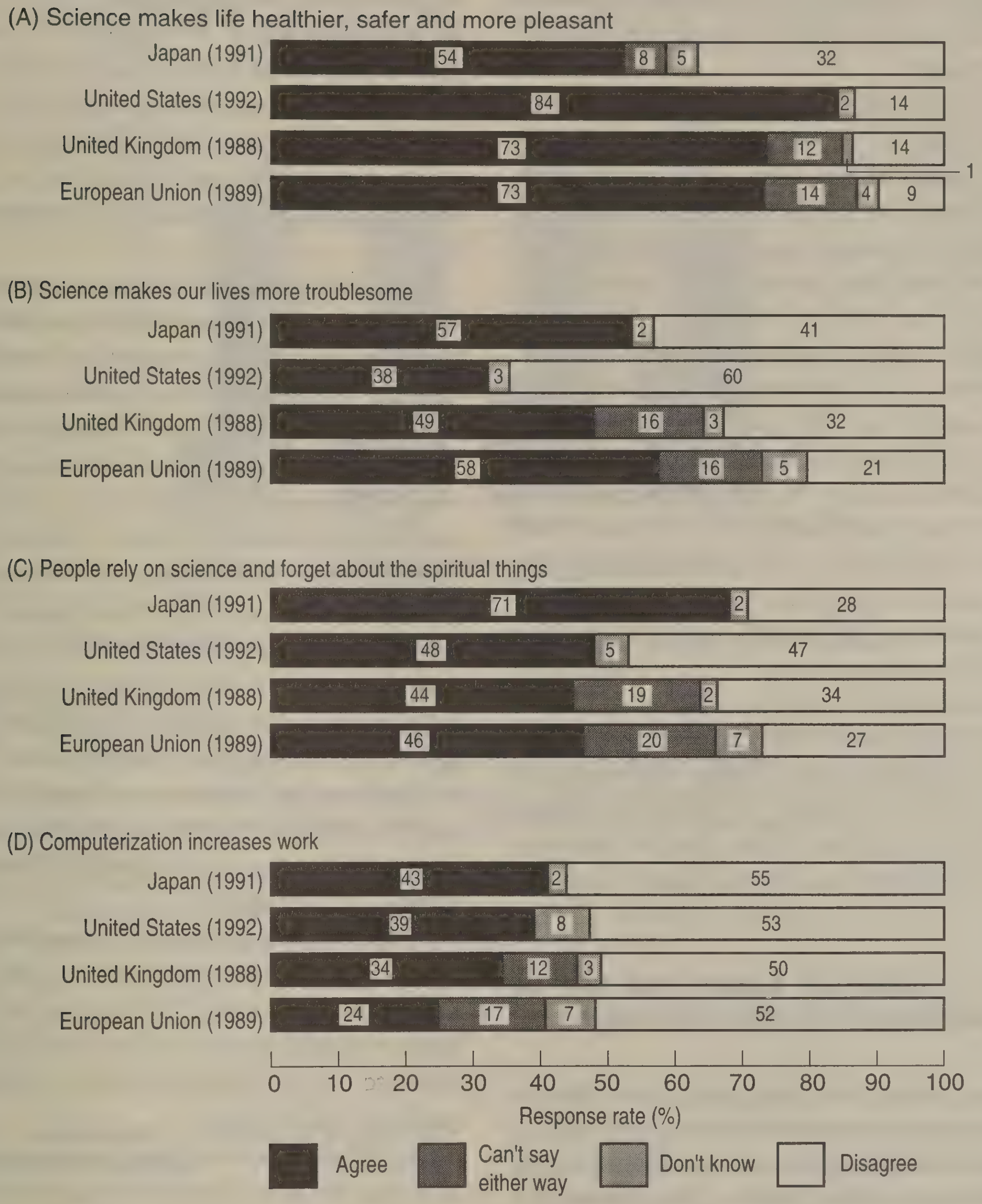


Figure 1-3-5 Attitudes concerning the influence of science and technology on society.

Source: "Science and Technology Indicators (1994)" by the National Institute of Science and Technology Policy, Science and Technology Agency.

Data Cited: Japan: "A Comparative Survey of Societal Perceptions of Science and Technology in Japan, the United States and Europe," National Institute of Science and Technology Policy, Science and Technology Agency, 1992.
United States: United Kingdom: European Union: "Europeans, Science and Technology" by J.R. Durant, et al and others.

greater use of its people's creativity to generate new value and provide the people with truly affluent lives.

Our country has reached maturity fully aware of this, and yet, we are in an age in which the newly industrializing economies and developing countries are still growing. The path ahead is difficult for the developed countries and they must increase their efforts to find new breakthroughs and seek to create new innovative markets. It goes without saying that to achieve these things, it is important to promote science and to come up with creative people in the fields of science and technology. The importance of these issues was also pointed out in last year's White Paper, but here we will look closer with the importance of actively tackling the problems of the provision of intellectual assets and conditions for creative activity extending into the next generation.

These endeavors are also expected to play an important role in creating a basis upon which to cope with the various global problems our country and the world are being confronted with. These endeavors may also be important to respond to the needs of our aging society, as well.

1.3.2.1 Intellectual Assets that Can be Handed Down to the Next Generation

An intellectual stockpile that is accessible to all plays an essential role in finding new technological breakthroughs and applying exisitng knowledge to new fields. This intellectual stockpile, which consists of the nation's accumulated scientific and technological knowledge, is considered a form of public good that cannot be "owned" in the conventional sense. It is also an inexhaustible resource that, in view of its importance, should be expanded further. In building an intellectual stockpile accessible to all, the right balance of basic research, applied research, and development in R&D is important. In Japan's case, the promotion of basic research is particularly crucial. A comparison of trends in past investment in basic research in Japan and the U.S. shows that despite recent increases in Japanese investment, the U.S. has made consistently large investments in this area, and by far exceeds Japan in accumulative investment. (Fig. 1-3-6).

The private sector carries out research and development to maintain and expand its corporate activities. Although some basic results are released through academic associations, etc., the information released is naturally limited. Therefore, the scientific and technological activities of the public sector — e.g., universities and national research institutes — should be expanded, which entails increased investment in government research and development. Last year's White Paper pointed out that it was desirable to expand research funding and ensure a future supply of researchers and research assistants so as to strengthen basic research. It also pointed out that it was important to improve research conditions to this end. Yet, in addition, it is desirable to have an expanded system promoting creative activity.

In addition to basic research, it is also important to organize and systematize so-called post-competitive technology (technology no longer used in production) so that it can be handed down to the next generation as an intellectual asset accessible to all.

The government now plays an important role in laying the groundwork for such intellectual assets, including related research and development and the training of the scientists and engineers who will make this possible. These efforts will serve as the basis for the development of measures to deal with a variety of global problems and an aging society, for contributions by science and technology to improve life and society and for the maintenance of a healthy and strong economy.

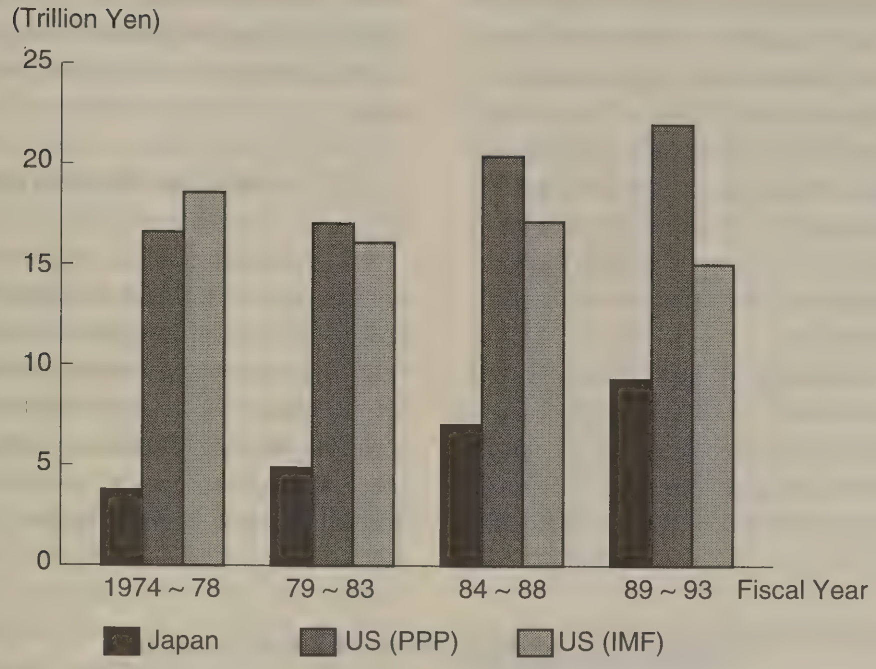


Figure 1-3-6 Investment in basic reseach in Japan and the United States.

Notes: 1. Real 1990 prices.
2. Investments in basic research for each fiscal year were converted to real terms using a deflator (a research expenditure deflator for Japan and a GDP deflator for the U.S.). Those of the U.S. were then converted into yen. The figures "U.S. (ppp)" are conversions based on OECD purchasing power parity. The figures "U.S. (IMF)" are yen price conversions based on IMF rates.

Source: Compiled by the Science and Technology Agency from "Report on the Survey of Research & Development", Statistics Bureau, Management and Coordination Agency, and "Science and Technology Indicators -1993", U.S. National Science Board.

1.3.2.2 Increased Institutional Encouragement of Creativity

With no outside models to follow, it is essential that Japan should generate its own original ideas and its own original science and technology. To promote this, and ensure that the ideas and concepts generated take root in society, Japan should expand its institutional encouragement of such activity and remove any institutional impediments to it. And while in the past Japan has often implemented such changes only in response to pressure from outside, from now on the necessary improvements should be initiated under the nation's own initiative and with the understanding that failure to do so will greatly impair stable growth in the future.

In addition to the creation of new markets based on unprecedented new insights, already existing knowledge will be applied to completely new fields. In any case, much will be expected of technological innovation, and thus, an enterprising, pioneering spirit will be necessary. For this reason, it is also important to strive for a society which appreciates people who have willingly taken daring risks and have succeeded. It is also very necessary to reward these people financially and to develop ample programs and facilities in which they can work.

The role played by business in developing new technologies and creating new industries is of extreme importance. It is also necessary to strive to provide an environment with good facilities in order to let businesses exercise their total creative capabilities.

In terms of cultivating original concepts and science and technology which has originality, we must stress diversity and excellence rather than one-sidedness and conformity. We must work to promote mobility for the capable personnel we need. We also must bring forward capable personnel regardless of age or gender and make good use of young and old, male and female.

1.3.2.3 Increased Mobility of Researchers

An important means of generating creative ideas, science, and technology is the promotion of flexible research systems of high mobility of researchers that allow researchers to move from one institute to the other more easily. Flexible research systems are those which promote mobility through selecting excellent researchers for limited or fixed periods of time. (Table 1-3-7)

Table 1-3-7 Summary of flexible research systems

	Main focus	Research mode	Status change	Number regularly selected (b)
Science & Technology Special Researcher System	Postdoctoral	Individual	Yes	40 people
Exploratory Research for Advanced Technology	Unrestricted	Group	Yes	As required (c)
Original Individual Research Development System	Unrestricted	Individual	Yes (a)	12 people
Frontier Research System	Unrestricted	Group	Yes (a)	As required (c)
Basic Science Special Researcher System	Postdoctoral	Individual	Yes	25 people
Special Researcher System	Postdoctoral	Individual	No	250 people
Overseas Special Researcher System	Postdoctoral	Individual	No	25 people
Special Researcher System (Cancer)	Postdoctoral	Individual	No	12 people (d)
Special Researcher System (New Programs)	Postdoctoral	Group	No	24 people
Osaka Bioscience Research Institute Set-term Researchers	Unrestricted	Group	Yes	As required
Sagami Central Chemical Research Institute Contract Researchers	Postdoctoral	Group	Yes	5 people (e)
Kanagawa Science & Technology Academy Researchers	Unrestricted	Group	Yes (a)	As required (c)

(a) In some cases holding two positions at the same time is allowed
(b) Number selected is based on actual figures for FY1992
(c) The number of people is selected on the basis of the number needed to carry out a particular project
(d) Selection every three years
(e) Average actual annual figure

Source: "Survey for the Creation of a Competitive Research Environment," Future Engineering Research Institute, March 1993.

The expectations arising from this sort of flexible research system where researchers are selected for fixed terms of service are as follows:

①At the end of his or her term of service, a researcher will look for a new research site and be transferred there.

②There will be a competitive search for a new position involved.

③This sort of fluid mobility will bring new encounters with different concepts and different ways of thinking to research sites and there will be intellectual competition resulting from the impact of interactive stimulation among researchers.

We will next consider what sort of effect a flexible research system has, based on a survey of researchers' perceptions of this kind of system ("Survey for the Creation of a Competitive Research Environment," Future Engineering Research Institute, March 1993 and March 1994), and what sort of issues are involved.

1.3.2.3.1 Effects on Research

More than 80% of researchers participating in flexible research systems perceived that the system is improving their research abilities. In appraisals of their own research abilities, 41% of researchers responded that the system "had a very great effect" in improving their research abilities, while 42% responded that it "had some effect." Among this group comprising approximately 80% of all participating researchers surveyed, 51% cited the improvement in their research abilities as being "an ability to think about things with a broader perspective" and 42% cited "the ability to control research based on a plan of one's own" as being very important.

Among those responding who were often the ones accepting researchers and controlling research, 63% of those in national research institutes and 57% of those in universities responded that they had fixed-term researchers in their research areas, while the percentage for those in the private sector was only around 21%.

Among the goals rated highly in expectations of flexible research systems by people in charge of research, 84% hoped that researchers would be able to broaden their knowledge through contact with researchers they had not known before, 83% hoped that researchers would be able to expand their networking with others and 61% hoped that researchers would be able to alter their special fields of expertise and expand their scope.

A little more than half of the respondents felt that researchers participating in a flexible system were extremely effective in stimulating their organization. If those who felt the researchers were somewhat effective are included, the proportion of respondents who viewed the researchers as being a stimulus to their organization goes up to 90%.

1.3.2.3.2 Issues to be Dealt with in Flexible Research Systems

The facts above represent the appraisals and expectations of flexible research systems, but there are still many things which need to be improved with regard to expanding the system and operating it more effectively.

Researchers participating in flexible research systems can be divided into groups according to their various motivations. 49% of these researchers (the largest percentage) responded that they wanted to improve themselves by going elsewhere to get special training, 42% responded that they were doing this while waiting for regular employment, 41% responded that they wanted to broaden their knowledge through contact with researchers they had not known before and 40% responded that they wanted a chance to use the skills acquired. It is to be noted that when comparing those participating in flexible research systems who have just gotten out of school with those who have not, 60% of those who have just gotten out of school were doing this while waiting for regular employment.

The overwhelming concern of participants was finding employment after the fixed term of research ended, followed by 38% concerned over their futures.

When they were asked about their desire to participate in this kind of system in the future, 14% of researchers said they would like to be active participants, while 65% said they would like to participate under certain circumstances. This shows the importance of concrete circumstances as one of the deciding factors. When those who responded that they would like to be active participants and those who responded that they would like to participate under certain circumstances were asked what conditions they regarded as necessary for participation, 64% said the assurance of freedom of research was the most important. 55% said they did not wish to be burdened with any work other than research activity. 42% said they wanted to be able to move freely back and forth between fixed-term research organizations and organizations with lifelong employment systems. 39% said they wanted a secure regular position after the research term ended.

Leaving aside the factor of the research environment, these results show that there is great concern over a researcher's own future after finishing a term in a flexible research system. From another viewpoint, the large number of people responding that they would like to participate under certain circumstances indicates that the present conditions in the system may be less than desirable. This indicates that links between flexible research systems and long term employment are not necessarily inherent ones and it is clear that some participants in flexible research systems are doing while waiting for regular employment.

Because this would stimulate researcher's abilities, help revitalize research institutes, create positive stimulation and contact among researchers, and produce various other benefits, such flexible research systems are expected to play a vital role in promoting the creative research that is becoming more and more important to Japan. However, some researchers are concerned that under such systems their livelihoods would be less secure (i.e., at the end of a contracted research period). Nevertheless, because of the benefits of such flexible research systems, Japan should clarify the position of the systems themselves and strive for systems that eliminate any uneasiness about status at the end of a predetermined research period, and under which the remuneration, funding and environments needed to attract researchers who are telented, capable and motivated can be provided.

It is not just a matter of the fluidity or mobility of Japanese researchers inside of Japan. There should be improvements in international personnel exchange arrangements to make it easier for researchers from other parts of the world to come to Japan for research work.

1.3.2.4 Centers of Excellence

A particularly important prerequisite for creative ideas, science, and technology is a shift in emphasis from uniformity to diversity and excellence. "Centers of excellence" (COEs) are an example of a science and technology policy that emphasizes such excellence.

A center of excellence is a central research institute with distinguished researchers, the latest research information, superior facilities and equipment, and an advanced support system, for instance. Some of Japan's research institutions are attracting researchers and research directors of an international caliber from other parts of the world. They also have access to facilities, equipment and experimental and measuring instruments needed for research of on an international caliber level. Nevertheless, there are still only a small number of foreign researchers coming to Japan for long-term research. This indicates that the facilities, equipment and experimental and measuring instruments and devices in Japan are still inadequate for research on an international caliber level and that there are not enough researchers or research directors capable of attracting researchers from other parts of the world.

In view of the path Japan has taken over the past fifty years to attain its current position of economic importance in the world, it is essential that Japan should create COEs that are commensurate with this position and which are capable of attracting talented foreign researchers to Japan. To do this, Japan should first secure researchers capable of international activity, and researchers with abilities that would be recognized in any nation. Thus, a research institute that wishes to become a COE should have the appropriate remuneration and employment systems for attracting the human resources it needs; establish the support system and research environment needed to attract the nation's most capable researchers; create a system whereby young researchers with the potential for becoming Japan's most telented researchers and research supervisors can study and enhance their skills under the tutelage of distinguished foreign researchers; and, finally, equip itself with the facilities and equipment needed to perform research of international caliber and produce results that are recognized by other nations.

Since the implementation of Special Coordination Funds for Promoting Science and Technology in FY1993, efforts have been made to support the development of the Centers of Excellence, to try and raise the levels of research in designated areas to the highest world levels in national research institutes and special corporations, to vigorously carry out basic research in an environment of constructive competition in those areas and to take active measures to make the results known overseas. Starting from FY1995, a system of assistance for universities was set up to actively support research institutes and research organizations in their efforts to become COEs through a program of Grants-in-Aid for Scientific Research.

It is important to continuously carry on long-range sustained efforts to develop COEs in the future.

1.3.2.5 Research Evalution

Just as important as the creation of COEs in scientific and technological advancement is the evaluation of research. There is evaluation prior to research when a research topic is put forward and evaluation of the results after there has been progress in this research. Research begins with a project idea put forward by a researcher and the assurance of funds, equipment and materials necessary for the carrying out of it. At this point, except in the case of small-scale projects, the need arises to assure funding, either internally from the researcher's institute or from an outside source. Since there are budgetary constraints, it is necessary to be selective about research topics and to evaluate these topics.

Although it is natural to look at a researcher's abilities and past achievements when assigning research topics and allocating funds, it is also important to look beyond this in order to encourage bold theories and new ideas. In short, what should be avoided is a system that discourages revolutionary, high-risk research topics by making researchers preoccupied with evaluation to the point that they focus only on projects likely to produce short-term results. In this respect, research institutes and the orgnizations that fund them should allocate funding in ways that give proper attention to bold theories and new ideas.

In connection with this, it is important to have diverse sources of funding available to suit the kinds of research. The existence of such a diversity of funding increases the scope of researcher selection and the freedom of research and contributes to the formation of a competitive research environment. Thus, it is important to set up and expand a variety of types of research funding, to offer this variety in a competitive context and to increase the number of sources of funding a researcher can select from. There must be strict evaluation of the research results. However, strict evaluation is difficult in basic research because the evaluation of the results of individual researchers is carried out through their presentations at scientific conferences at various research institutes in Japan and abroad and through the publication of articles in prestigious international journals and scientific magazines. In the private sector, discretionary systems have been set up in which there is only a limited amount of the research results available and not of hours of work clocked in. There has also been some introduction of flat annual salary systems, and in these cases, evaluation of results and monitoring of achievements becomes extremely important.

Recent years have seen an increase in the number of Japanese research institutes that employ outside evaluation — that is, evaluation committees comprised of prominent outside individuals, even foreign nationals — not only to evaluate individual research projects, but also to evaluate the various aspects of institute administration. An outside evaluation of the Physics Department of the Faculty of Science at University of Tokyo was made in 1993 and the results were made public. The first session of the Research Advisory Council (RAC) of the Institute of Physical and Chemical Research (RIKEN) was held in June 1993, in which an overall outside evaluation of the activities of the institute was made. An outside evaluators' report on the National Research Institute for Metals of the Science and Technology Agency was publicly issued in August 1994. Evaluation committees made up of outstanding Japanese and foreign authorities in their fields were set up for each research institute to appraise the COE development program funded by the Special Coordination Funds for Promoting Science and Technology described earlier.

This type of evaluation should be promoted, and the number of research institutes that employ it increased, in order to make full use of researchers' abilities and enable them to achieve their research goals.

1.3.2.6 Sustaining Japan's Problem Solving Abilities

Japan has many issues to deal with, such as global environmental problems, cutting back on the consumption of energy and resources and coping with an increasingly aging society.

There have been problems that Japan has encountered before or at the same time as other nations yet responded to relatively adequately despite the absence of outside models to refer to. Well-known examples include regulations and technological responses to pollution and the development and introduction of energy-conservation technology in response to the oil crises.

As these examples demonstrate, Japan can be justly proud of its overall societal ability to apply its scientific and technological capabilities in comprehensively responding to a problem or striving towards an objective once this problem or objective has been clarified. These problem solving abilities will continue to be a valuable asset and should be maintained and enhanced. There is a special need to make active and appropriate use of their abilities in future, to deal with the global environmental problems Japan is confronted with, to deal with an aging society, to strive for social and individual prosperity and to solve other new problems. Concerning these abilities, we must look ahead to the society of the future, anticipate the times ahead, grasp the essentials of the problems, clarify the technological problems that need to be tackled to deal with these problems and determine how to set precise technological goals and concrete topics for research and development. In an era when there are no outside models to follow, a keen power of discretion, a broad range of knowledge to support this, the ability to work things out in our own minds and the creativity to back that up are very much needed.

1.3.3 The Countributions of Science and Technology to Society and Daily Life

The viewpoint in Japan after the War was that a prosperous economy would bring about individual prosperity. Thus, economic prosperity was pursued and there was great economic growth.

Yet, while this has brought about material prosperity, there is uncertainty about the future due to problems of coping with an aging society, cutting back on the consumption of resources and energy, global environmental problems, safety and disaster prevention, etc. The people do not completely secure think they are prosperous. It is, therefore, necessary to create a social structure with more flexibility, which promotes a feeling of security in life by trying to work out the means to give people a feeling of real prosperity and reduce feelings of uncertainty. The role played by science and technology in this is likely to be greater than ever before. It will be necessary to employ science and technology in the areas of health maintenance and medical advances, improvement of people's living environment, provision of a firm socioeconomic base and safety and disaster prevention, while keeping the importance of living things in mind. This will be necessary in order to satisfy new demands made by the people and to respond to future social problems and problems closely related to the people's lives.

Using these perceptions as a point of departure, in Section 3 of this document, we will look at the way science and technology must be structured so as to provide a feeling of affluence.

1.3.3.1 The Public's Expectations of Greater Welfare/Amenity through Science and Technology

In response to segments of Japanese society that, despite the current economic affluence, decry their inability to experience the country's affluence in their daily lives, science and technology will have to do even more to enable this affluence to be experienced firsthand in daily life.

People's future expectations of science and technology include economic development, improvements in efficiency and greater convenience. These expectations include increasingly greater expectations in terms of solutions to global environmental problems, conservation of energy and resources, improved safety and enhanced welfare.

"The Influence of Science and Technology on Humans/Society." reported in March 1994 by the National Institute of Science and Technology Policy, divides the areas where science and technology play an important role into "the Home," "Industry," and "Society," and determines the importance with which the public views the role that science and technology plays in each. The results of this survey reveal high expectations with respect to the role of science and technology in the area "Society," including health and medicine, environmental conservation and safety, and natural resources and energy (Fig. 1-3-8).

The same survey also dealt with problems of prediction technology, the time specialists thought it would take to put this type of technology to practical use and important technological matters that people felt it was important to put into practical use. Most subjects of the survey perceived that issues in the areas of medical care, health, disaster prevention, safety and the global environment either needed swift solutions or were extremely important. There is a need to consider what influence the time that people anticipated there would be practical applications by specialists had on the responses, but the results of this survey are representative of the general expectations of science and technology in such societal areas as hygiene, medical care and disaster prevention. Wishes expressed were for such things as the development of drugs to prevent cancer, a cure for AIDS, the possibility of predicting earthquakes of M7 or above on the scale several days ahead, controls on carbon dioxide emissions, predictions of volcanic eruptions, a cure for senility and the like (Table 1-3-9).

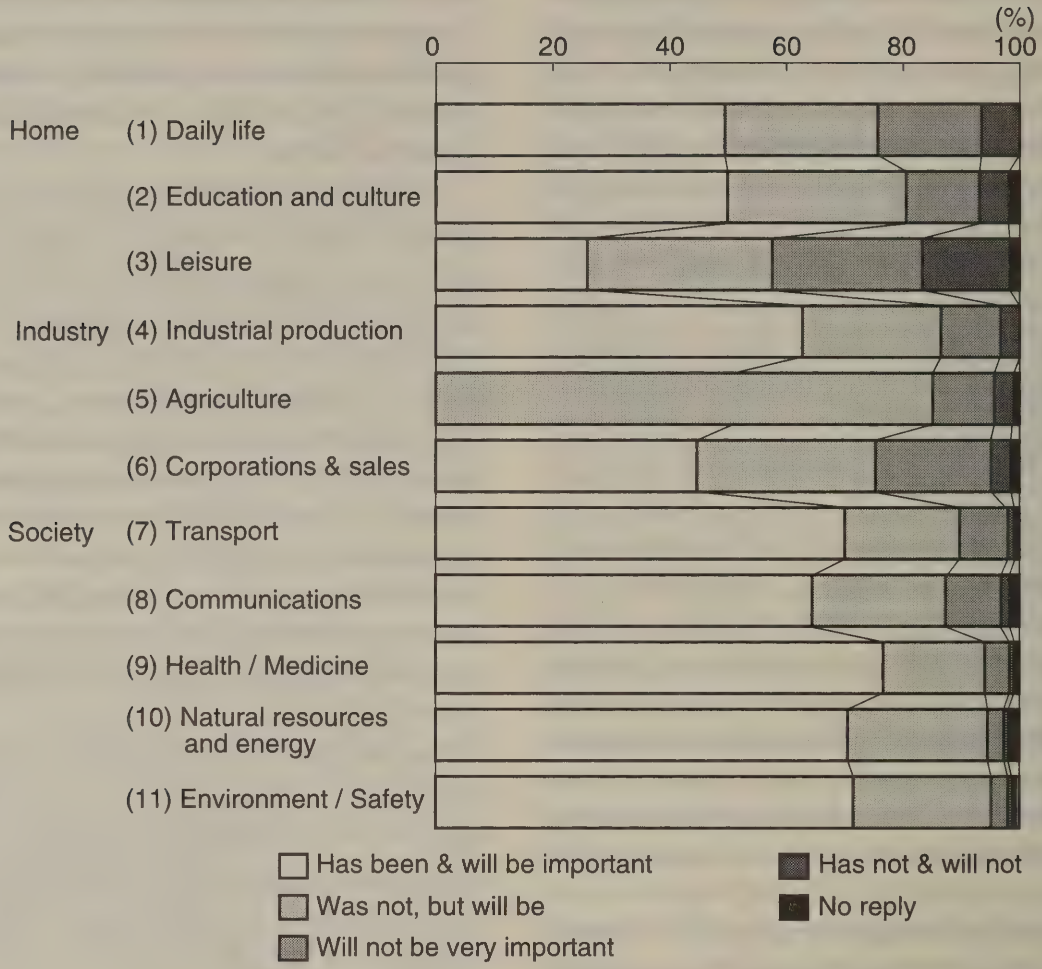


Figure 1-3-8 Areas where science and technology play an important role.

Source: "Survey of the Influence of Science and Technology on People and Society," National Institute of Science and Technology Policy, Science and Technology Agency, March 1994.

1.3.3.2 Technology's Past Emphasis on Production

One of the reasons for the inability to translate Japan's affluence into welfare/amenity of life is that Japanese technology, although at international levels in the field of production, has not always contributed sufficiently to society and people's daily lives.

In the Science and Technology Agency's "Survey on Private Enterprises' Research and Development (FY1990)," in response to a question concerning whether the technology possessed by businesses surveyed was at a level adequate for affluent living, 11.0% of the businesses surveyed responded that it was rather inadequate and 58.4% responded that it was somewhat inadequate. Combining these responses, we find that close to 70% of businesses regarded their technology as inadequate. On the other hand, only about 25% of the businesses responded that their technology was adequate.

Table 1-3-9 Expectations of science and technology (Important technologies which people want realized sooner than anticipated).

(unit: %)

	Need for early realization	Regarded as extremely important
Drugs to cure cancer will be developed (2013)	78.0	66.8
A cure will be found for AIDS (2006)	70.8	66.2
It will become possible to predict earthquakes of M7 on the scale or above several days ahead of time(2010)	67.0	59.3
Control of carbon dioxide emissions (2015)	60.0	54.5
Prediction of volcanic eruptions (2006)	55.5	54.2
Treatment for senility (2015)	63.5	53.0
Naturally decomposing plastic (2003)	56.0	43.0
Recovery of waste from homes and workplaces (2001)	52.3	40.3
Widespread use of solar heating and cooling (2004)	45.8	30.8

Notes: 1. Dates in parentheses ( ) are those when specialists anticipate practical realization of technology.
2. Tabulation of data regarding technology which respondents wanted realized earlier than anticipated by specialists.

Source: "Survey of the Influence of Science and Technology on People and Society," National Institute of Science and Technology Policy, Science and Technology Agency, March 1994.

When the businesses that had responded that their technological levels were rather or somewhat inadequate were asked their reasons for thinking so, 42.7% responded that it was because they lacked enough research specialists, 22.6% responded that the course they had followed so far had not made this a problem for them, 15.9% responded that there had not been much need for better technology and 14.2% responded that technological development was difficult for them. The lack of research specialists may - to some extent - be regarded as an indication of the degree of desire for research and development in a business. This response, together with the response that the course they had followed so far had not been a problem, may indicate that businesses felt that there were no particular problems in the way they had done things so far (Fig. 1-3-10).

1.3.3.3 Technology and the Social System

A survey of researchers in the private, university and government sectors was carried out by the Science and Technology Agency in 1990. It was known as the "Survey on High-Tech Researchers and Engineers." This survey contrasted Japan's production of high-quality manufactured products employing the highest world levels in industrial technology with an insufficient use of available technology to provide facilities providing the infrastructure of daily life such as comfortable living space, utilization of subterranean space, city planning and the like. 51.7% of the high-tech researchers surveyed said they agreed entirely that this was the case and 44.0% responded that they agreed to some extent. These two groups together comprise a total of 95.7% who consider the contributions of industrial technology regarding the infrastructure of daily life.

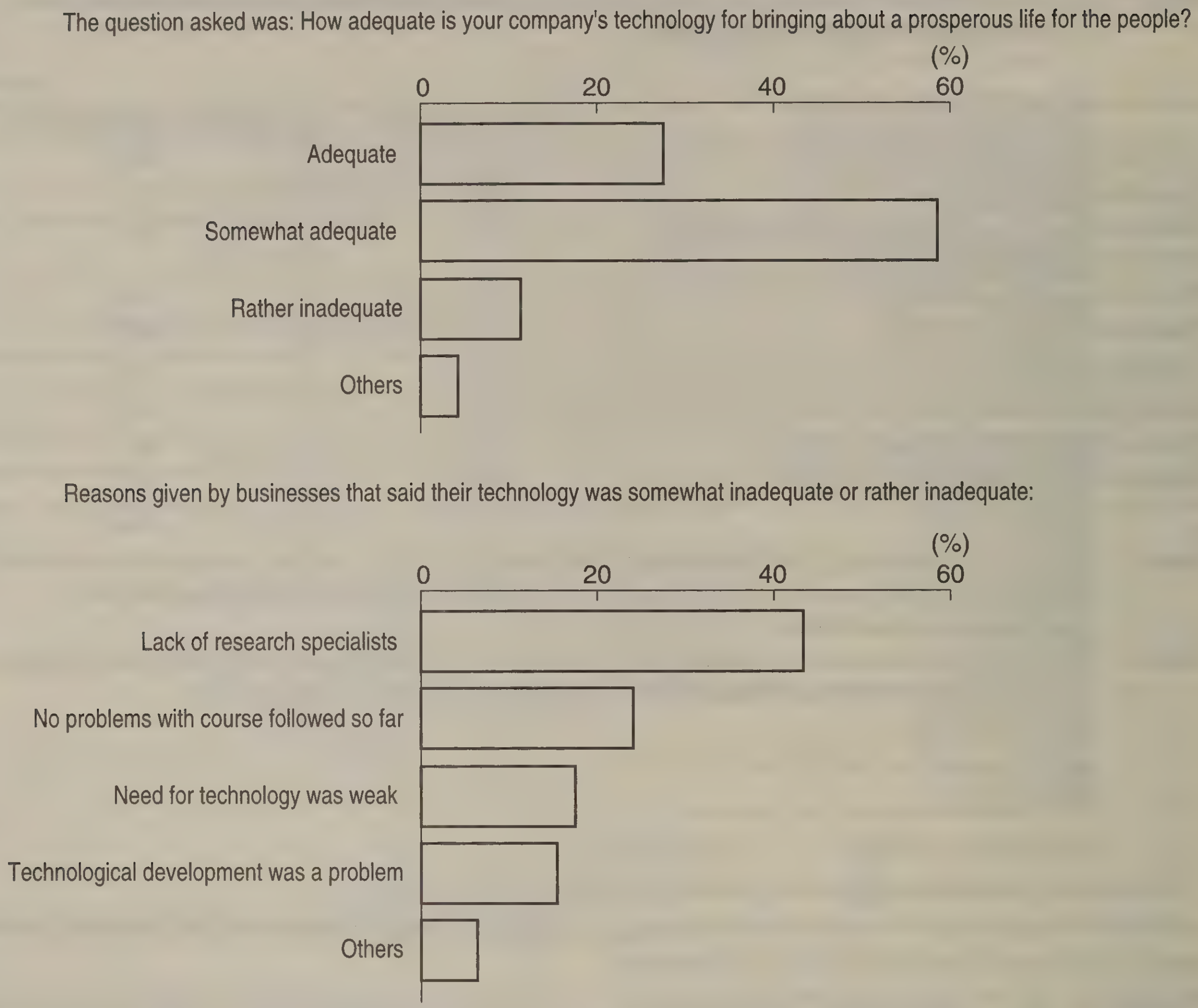


Figure 1-3-10 Private sector technology and a prosperous life for the people.

Source: "Survey on Private Enterprises' Research and Development (FY1990)," Science and Technology Agency.

A very large number of the respondents (56.2%) cited insufficient investment in public utilities and insufficient utilization of technology as reasons for the inadequate contributions made to the infrastructure of daily life (Fig. 1-3-11). While approximately two-thirds of advance technology has been developed by private industry, there are cases where people think that the social system (regulations, economic restraints, etc.) serves as an impediment regarding the progress in the use of technology (Fig. 1-3-12). Thus, the social system is seen as being a major factor affecting the use of technology as far as the private sector is concerned. It is also difficult for the private sector to satisfy consumer needs effectively when economic restraints obscure the actual supply and demand situation.

Emphasis has been given to mass production efficiency and convenience as science and technology have advanced and material needs have been satisfied. Yet, there are inadequacies

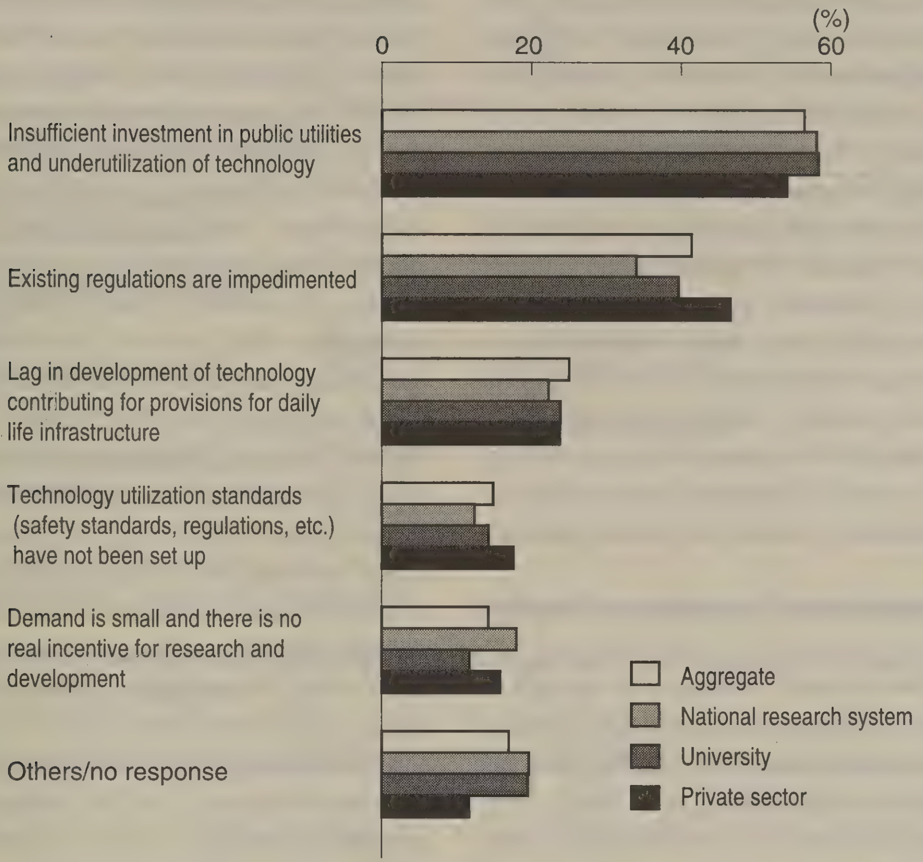


Figure 1-3-11 **Reasons why industrial technology's contribution to the infrastructure of daily life is inadequate.**

Source: "Survey on High-Tech Researchers and Engineers (FY1990)," Science and Technology Agency.

The question asked was: The number of cases in which available outstanding technology will not be used to its advantage because of social system impediments (regulations, economic restraints, etc.):

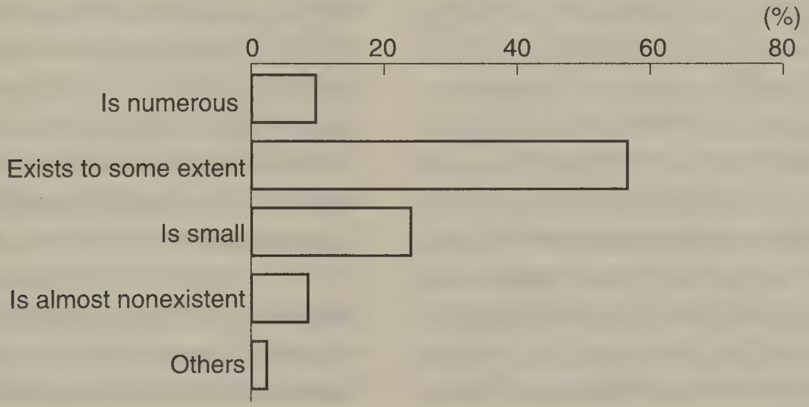


Figure 1-3-12 **Technology and the social system.**

Source: "Survey on Private Enterprises' Research Development (FY1990)," Science and Technology Agency.

in science and technology related to daily life and social systems since these tend to be less suited to standardization, uniformity, mass production and mass consumption. While there have been great achievements by the industrial sector in further improving the quality and reliability of mass-produced goods in response to the stringent demands of the consumers, there has not been sufficient interaction between manufacturers and consumers. Problems concerning the assurance of funds for development is also of great concern. There is also the question of who should be responsible for providing these funds, as well as problems of the motivation of technicians to foster this development.

1.3.3.4 Emphasis on Comprehensiveness

There has been a great tendency for progress in technology to be made in individual specialized areas by groups of scientists and engineers organized separately according to scientific and technological subdivisions, specialization and systemization. Too much attention towards the quest for the convenience of individual manufactured goods and services and a lack of consideration regarding the prosperity of ordinary people may be factors involved in the lack of feeling of prosperity in an era of material affluence. It is therefore necessary to promote research and development based on a holistic view of mankind, constantly keeping the prosperity of ordinary people in mind. It is also necessary to actively and positively utilize the results of such research and development. The current tendency in science and technology is to reduce things to their constituent elements. For instance, it is common to look at an illness not as the suffering of a patient, but as a malfunction of the internal organs that make up the human body and to seek to restore their proper functioning. The problem with science and technology based on reducing things to their constituent elements is that it overlooks things that cannot be reduced in such a way. It is also possible to think of things in terms of separate elements and as lacking a comprehensive view of nature. To remedy this, comprehensive science which has a grasp of problems as a whole is necessary. Efforts must be made to integrate science and technology, which have become subdivided and compartmentalized. There is a need to bring together a broad range of separate fields of research and development and strengthen ties between the natural sciences and humanistic and social sciences.

According to the 1990 "Survey on High-tech Researchers and Engneers," measures to promote scientific and technological research and development relevant to life cited by respondents included the promotion of the acceptance of research and development by society and the system (50.3%) and the promotion of joint research with researchers in the humanistic and social sciences (43.9%) (Fig. 1-3-13). Accordingly, there is a need for science and technology to serve the goals of social prosperity, to create conditions which will promote the acceptance of science and technology by the system and to work to integrate subdivided and compartmentalized science and technology. Up until now, males have overwhelmingly been predominate in science and technology and have also played the dominant role in the social application of research and development results. Science and technology do not reflect the perspectives of all parts of the population, especially the views of women. This lack of various perspectives begins with research and development. As women make up about half of the national population, there should be greater encouragement for participation of women in the fields of science and technology and assistance should be provided for their participation. It is hoped that the participation by women in the field will play a great role in helping science and technology serve to promote a prosperous life and that their participation will also help research and development reflect the viewpoints of consumers and people involved in daily life.

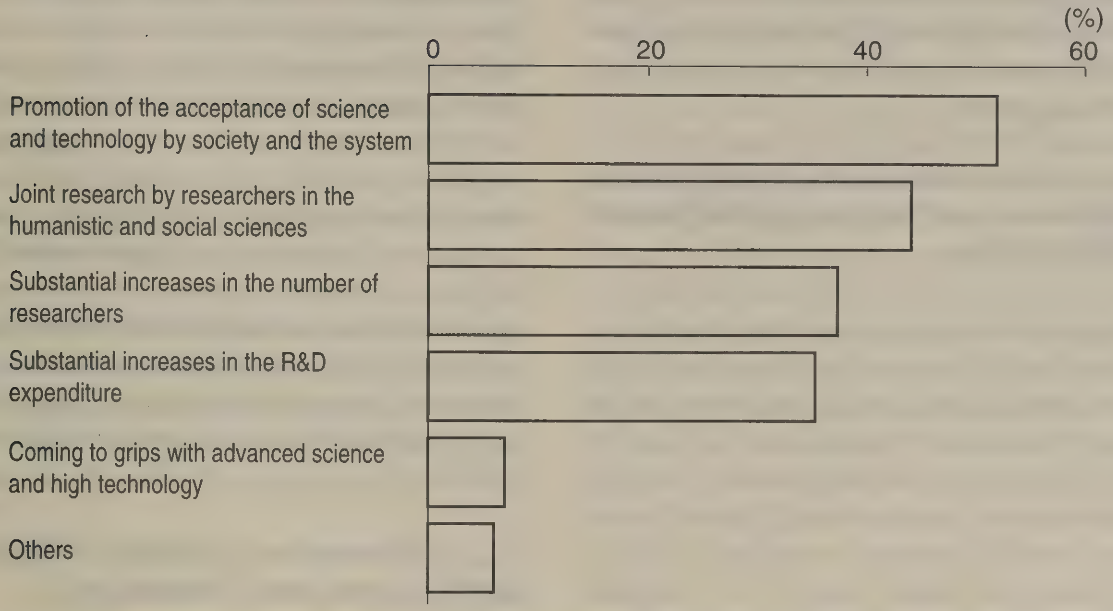


Figure 1-3-13 **Measures to promote research and development in science and technology closely related to daily life.**

Source: "Survey on High-Tech Researchers and Engineers (FY1990)," Science and Technology Agency.

1.3.3.5 Emphasizing People and Responding to Diverse Needs

It is more important than ever before that Japan deals with the aging of its population, to expand the sphere of activity for women, to provide assistance for those with disabilities, to furnish a wider range of choices to suit a diversity of values, to assure a life of prosperity and respond to other such social issues. With the contributions of science and technology to society and daily life expected to become even more important, it is time for an approach that emphasizes the needs of people.

Such an approach should be centered around those who use technology, and should seek to adapt technology to people, rather than require people to adapt to technology. Essentially important to science and technology for society and daily life is interface between technology and those who actually use it. Just as eliminating excessive functions and keeping only the basic ones often improves ease of use, interface developed with high-technology but which does not make users or those around them conscious of that technology would be suitable for some devices that are used to supplement or take the place of human functions. In short, interface designed with the ease of use of those who actually use it in mind is important to technology.

There is a need for a system that takes up and responds to a variety of needs and which is actively focused on scientific and technological activity carefully taking in the needs of the people. We must conceptualize responses to these needs in the form of manufactured products and services, along with the technological ability to sustain them. It is important not to respond to problems one at a time, but rather to have an integrated approach as regards them.

In responding to detailed needs, there are many cases where demand is not so great. In these cases, it is important to promote standardization and joint development by making good use of the already existing technology and taking efficiency into account as regards research and development.

1.3.3.6 The Government's Role in Promoting Science and Technology for Society and Daily Living

With respect to society and daily living, government itself is in part a consumer and at the same time responsible for creating new demand through regulation or deregulation in some respect. It is desirable for government to actively promote new technology through public investment in various aspects of society and daily liging in ways that ensure that new technologies are used by society effectively and in ways that enhance the public's welfare. And although proper regulations and standards are also important, regulations should be formulated to ensure safety and compliance, etc., without unnecessarily limiting a technology's potential.

In promoting science and technology intended to enhance society and daily living, it is first of all necessary to accurately ascertain the needs of society and the public and to expand promotion of the research and development required to satisfy these needs.

Specific social and daily life needs may be problems and there are cases in which the private sector cannot be expected to make active efforts to come to grips with them. From the consumers' viewpoint, there may be many cases where it is not clear who is going to provide the equipment or services they need. In such instances, information technology which has been rapidly developing in recent years can be expected to serve as an intermediary between consumers and providers of goods and services by gathering information on consumer needs, determining the sorts of equipment and services needed and conveying this information to people engaged in developing them. A great deal is to be expected from the private sector in terms of creativity, energetic activity and technological ability in research and development relevant to society and daily life. Since, however, there are risks involved that are difficult for the private sector to grasp with, it is important for government to reduce these risks and actively participate with the private sector in these areas. Government also has a major role to play in strengthening an integrated focus in many scientific and technological areas and developing basic, fundamental technology. The basic research programs of the Special Coordination Funds for Promoting Science and Technology related to daily life and society are examples of the Government coming to grips with issues in this manner.

1.3.4 Promoting Society's Dialogue with Science and Technology

In an analysis of the state of Japanese mining and manufacturing in a White Paper on Technology soon after the end of the War, it was stated that the "general interest in science and technology in our country has been very low up until now and the existing interest was superficial, with little real understanding ever being achieved." There were advances in the understanding of science and technology in the course of high postwar growth and interest in science and technology reached a point of true understanding. Due to the important role played by science and technology in the economy, a heightened interest in science and technology appeared among those deeply involved in activities related to the economy. Among the people in general, however, there were changes in the perception of and trust in scientific and technological progress as pollution, damage to the natural environment and other problems arose as side-effects of high economic growth. Problems involving safety and global environmental problems and the like became more prominent and people even appeared to lose interest in science and technology.

Section 4 focuses on society's relationship with science and technology—for it is this relationship that determines the success of science and technology's contributions to human welfare — looks at society's awareness of science and technology, and considers the kind of approach that should be taken to enhance this awareness.

1.3.4.1 Society's Awareness of Science and Technology

1.3.4.1.1 Interest in Science and Technology

One indicator of public interest in science and technology are participants' response to questions regarding "science- and technology-related news and topics" in the Public Opinion Surveys on Science and Technology and Society. As pointed out in the 1993 White Paper on Science and Technology, in recent years the percentage of adults expressing an interest in scince- and technology-related news and topics has on the whole been rising among those 30 or older, but falling among those in their twenties. The results of February 1995's Public Opinion Survey on Science and Technology and Society reveals the same growing disinterest in science and technology among young people (Fig. 1-3-14).

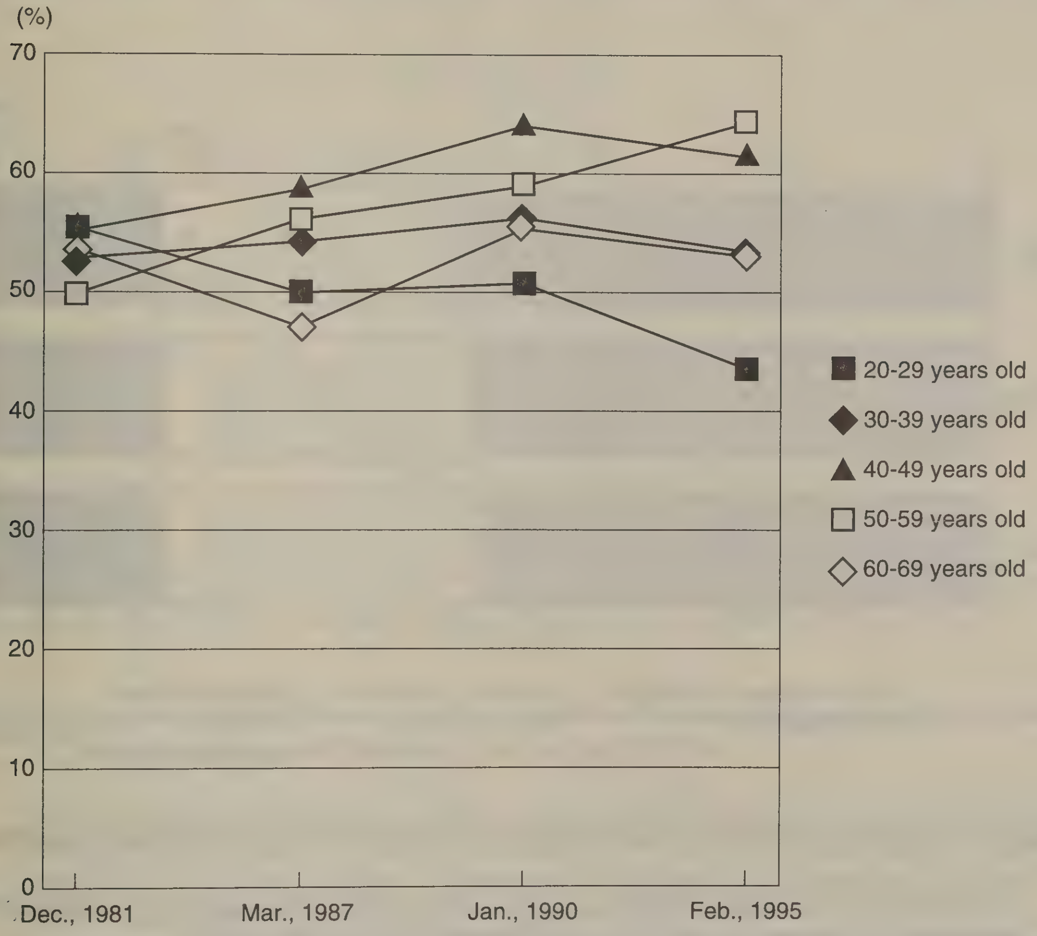


Figure 1-3-14 Changes in interest in science- and technology-related news and topics.

Note: The above indicates the percentage of participants who selected the response "Very interested" or "Somewhat interested" in response to the question "Are you interested in science- and technology-related news and topics?"

Source: "Public Opinion Survey on Science and Technology and Society," Prime Minister's Office.

1.3.4.1.2 Consciousness of Scientific and Technological Progress

1.3.4.1.2.1 The Positive and Negative Aspects of Science and Technology

It is said that there are positive as well as negative aspects of science and technology development. Survey results regarding the question "overall, which aspect do you think outweighs the other?" show that, in recent years, those who think that science and technology have more positive than negative aspect have accounted for slightly over half of the tolal. (Fig. 1-3-15)

Many people already view scientific and technological progress as contributing to higher standards of living. From this point, we would like to take a look at the overall appraisals of the positive and negative aspects of science and technology in relation to perceptions of the contributions of science and technology to raising the standards of life. There were many people who thought science and technology had raised the standards of life among those who thought that science and technology had many positive aspects. There were few people who thought that science and technology had worsened the standards of life. There were a fair number

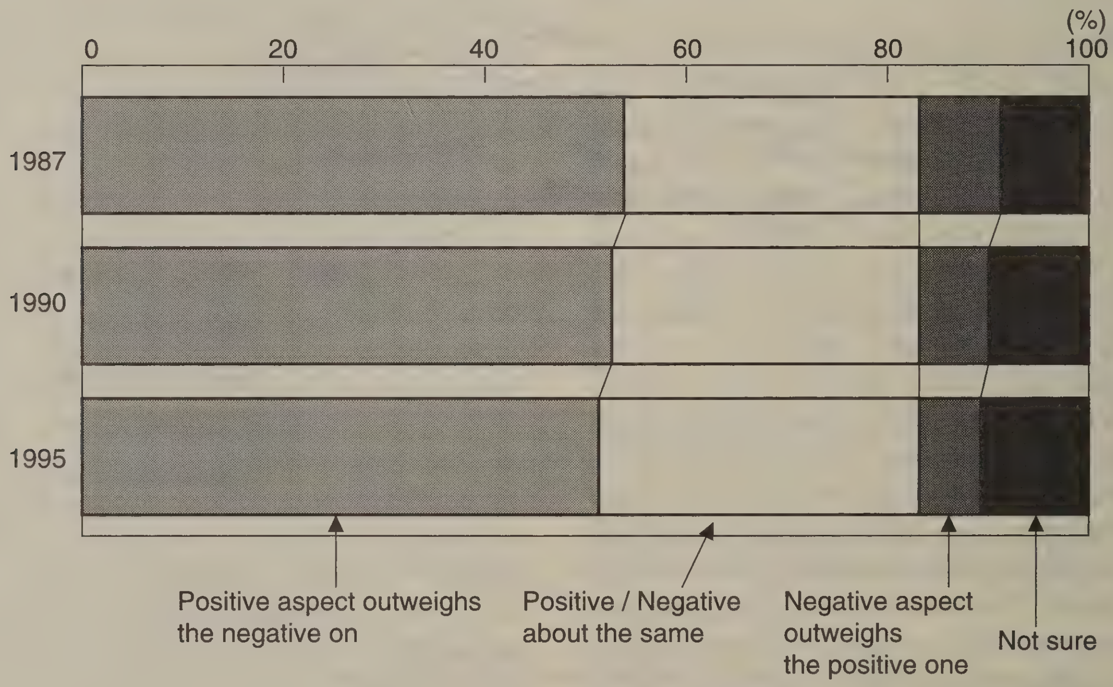


Figure 1-3-15 The positive and negative aspects of scientific and technological progress.

Note: The question was, "Although there are both positive and negative aspects to scientific and technological progress, which do you think outweights the other overall?"

Source: "Public Opiniion Survey on Science and Technology and Society," Prime Minister's Office.

among those who responded that science and technology had many negative aspects that thought science and technology had worsened the quality of life (Fig. 1-3-16). It appears from this that consideration of the extent to which science and technology contributed to improvements in the quality of life had a great influence on appraisals of the overall positive or negative aspects of science and technology. Their appraisal of the positive aspects of science and technology and progress would be improved if science and technology is used to raise standards of living in ways that enable the public to experience these improvements directly. In this respect, it is important that the people directly experience and understand the contribution of science and technology in society, daily life, and a wide array of other areas.

1.3.4.1.2.2 Increased Specialization and Subdivision

In the public opinion survey mentioned above, the total of those who expressed extreme worried or some worried over the subdivision of science and technology and the total of those who felt that it could only be understood by specialists exceeded 60% of respondents, indicating that many people are concerned about the specialization and subdivision of science and technology and the fact that they can no

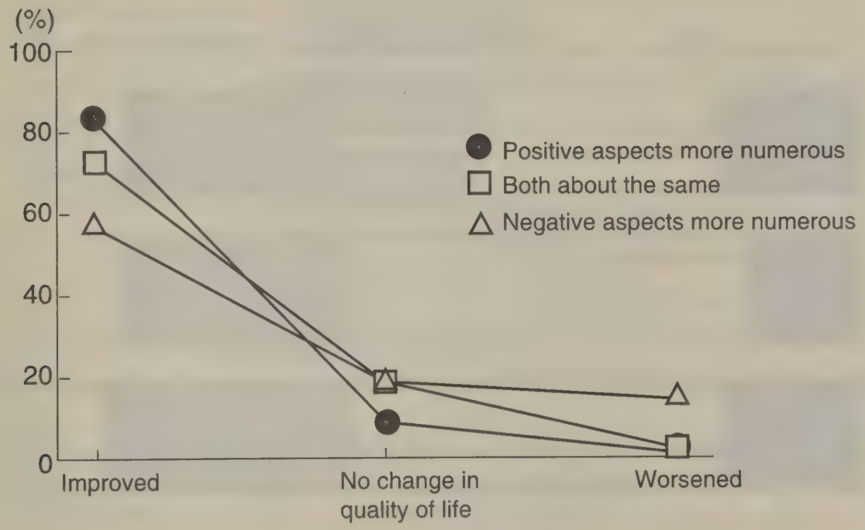


Figure 1-3-16 **Appraisal of positive and negative aspects of science and technology and the effects of science and technology on the quality of life.**

Note: As for percentages in the graph, percentage of those responding that the quality of life had improved, not changed or worsened, are shown within each of the three groups showing that there were more positive aspects of science and technology, that positive and negative aspects were about the same and that there were more negative aspects.

Source: "Public Opinion Survey on Science and Technology and Society," Prime Minister's Office, January 1990.

longer understand it (Fig. 1-3-17).

1.3.4.1.2.3 Concerns Generated by Scientific and Technological Progress

In terms of public concerns generated by scientific and technological progress, "The Influence of Scinece and Technology on Humans/ Society" was reported in March 1994 by the National Institute of Science and Technology Policy. This survey showed that more and more people were concerned about the global environment, pollution, and safety — i.e. the appearance of global environmental problems that threatened their existence, the increases in pollution, the concern for the safety of food products and the major damage that society could suffer if large-scale concentrated control systems using computers happened to fail (Fig. 1-3-18).

1.3.4.1.3 High-tech Medical Technology and Ethics

There are cases in which advances in science and technology affect people's most basic ways of thinking. This is especially to be noted in the field of high-tech medical technology.

The "Public Opinion Survey on Ethics in Medical Care" performed by the Prime Minister's Office in October 1990, studied people's concern

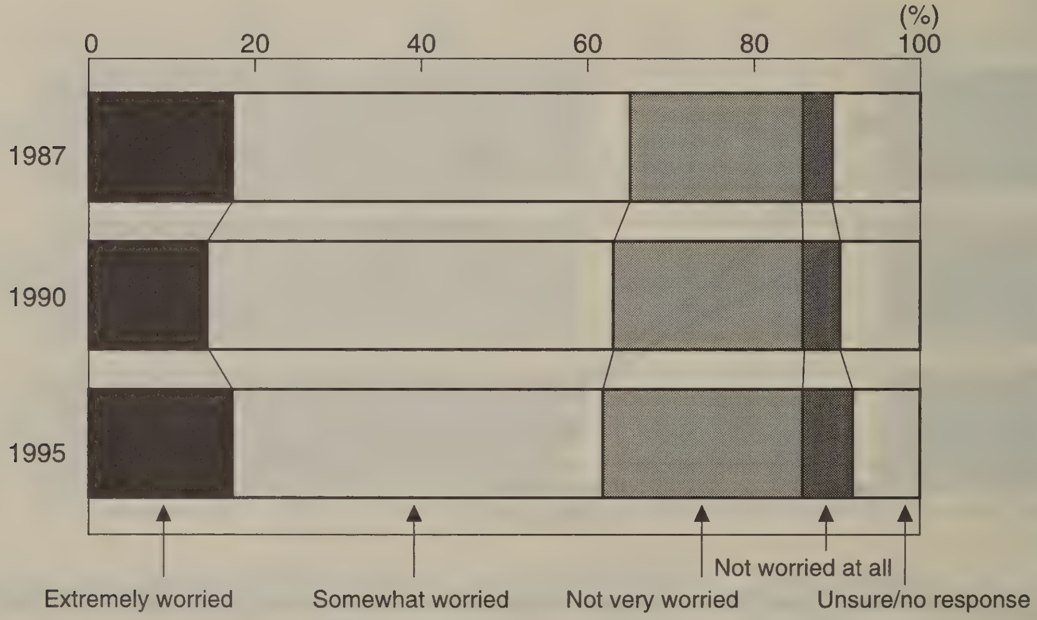


Figure 1-3-17 People's attitudes toward subdivision in science and technology.

Note: Answers were in regard to how respondents felt about the statement that "science and technology are subdividing more and more and I feel worried that only specialists can understand things."

Source: "Public Opinion Survey on Science and Technology and Society," Prime Minister's Office.

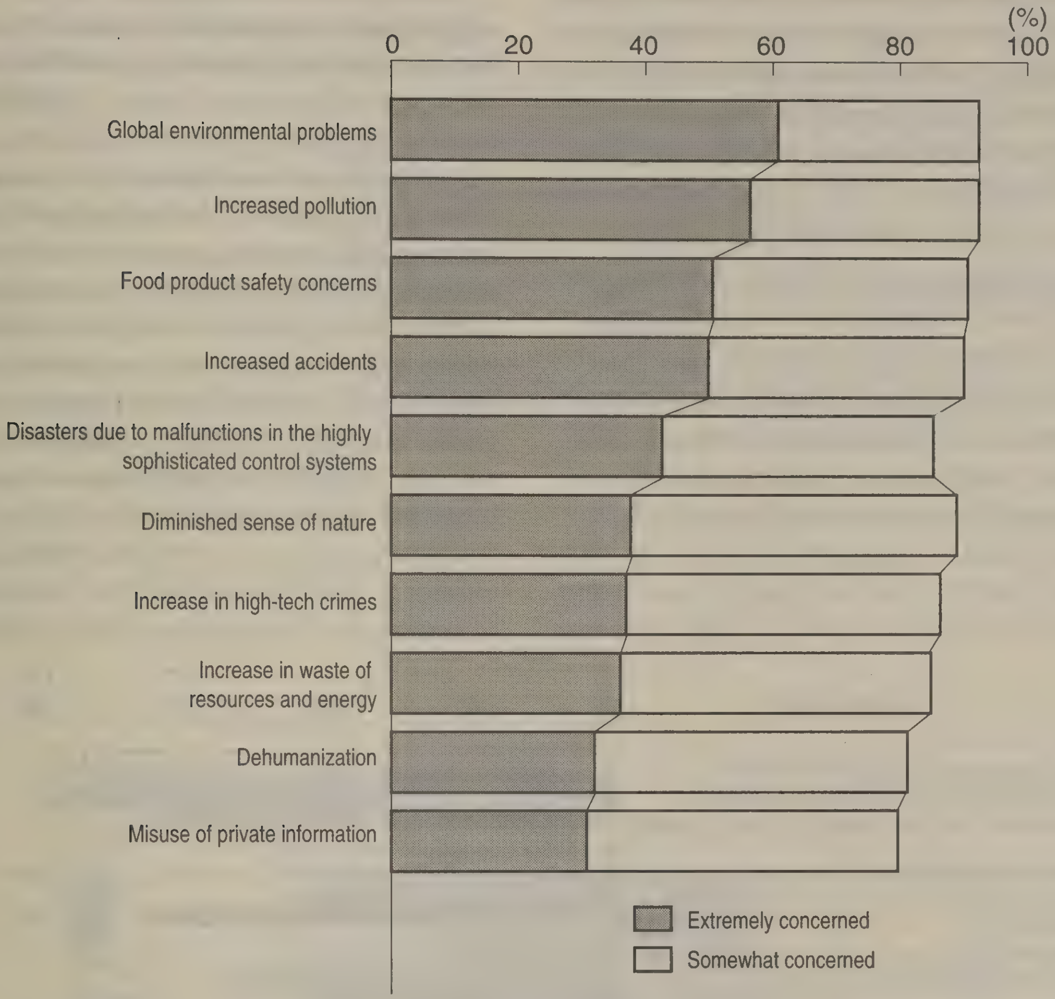


Figure 1-3-18 Concerns involved in the progress of science and technology.

Source: "The Influence of Science and Technology on Humans/Society," National Institute of Science and Technology Policy, Science and Technology Agency, March 1994.

over organ transplants, in vitro fertilization, prenatal diagnostic screening and other such high-tech medical technology. People expressing extreme concern or some concern made up about 70% of the respondents. A number of areas was also cited as instances in this survey where there were questions about whether it was necessary to examine the ethics involved or not (including brain death, organ transplants, medical treatment in terminal cases, in vitro fertilization, gene therapy, prenatal diagnostic screening, etc.). 74.5% of the respondents said that it was necessary to examine the ethics involved, 6.3% said an examination of ethics was not particularly necessary and 19.2% said they did not know. It appears that a great many people regard an ethical examination of high-tech medical technology as necessary.

When respondents who said that an ethical examination was necessary were asked how the examination should be carried out, 36.5% answered that there should be joint consultation on the spot among concerned parties on a case-by-case basis, including the person affected by the technology, relatives and doctors. 23.9% responded that there should be consultations involving people from various fields, with standards decided on the basis of societal consensus. 23.1% believed that doctors and other specialists concerned with medical care should have discussions at scientific conferences to determine the standards. The results indicated that there were relatively more people who stressed the consensus of those concerned, although many people also supported the establishment of the standards (Fig. 1-3-19).

Looking at the educational backgrounds of respondents, we find that with the higher the level of education, there is a lower frequency of "don't know" responses. It should also be noted that the number of people who stressed that there should be consultations involving people from various fields, with standards decided upon on the basis of societal consensus, is on the increase. The results of the survey generally seem to indicate that the higher the education level of the respondents, the greater interest there was in science and technology and the greater the tendency there was toward a solution involving the establishment of standards based on societal consensus.

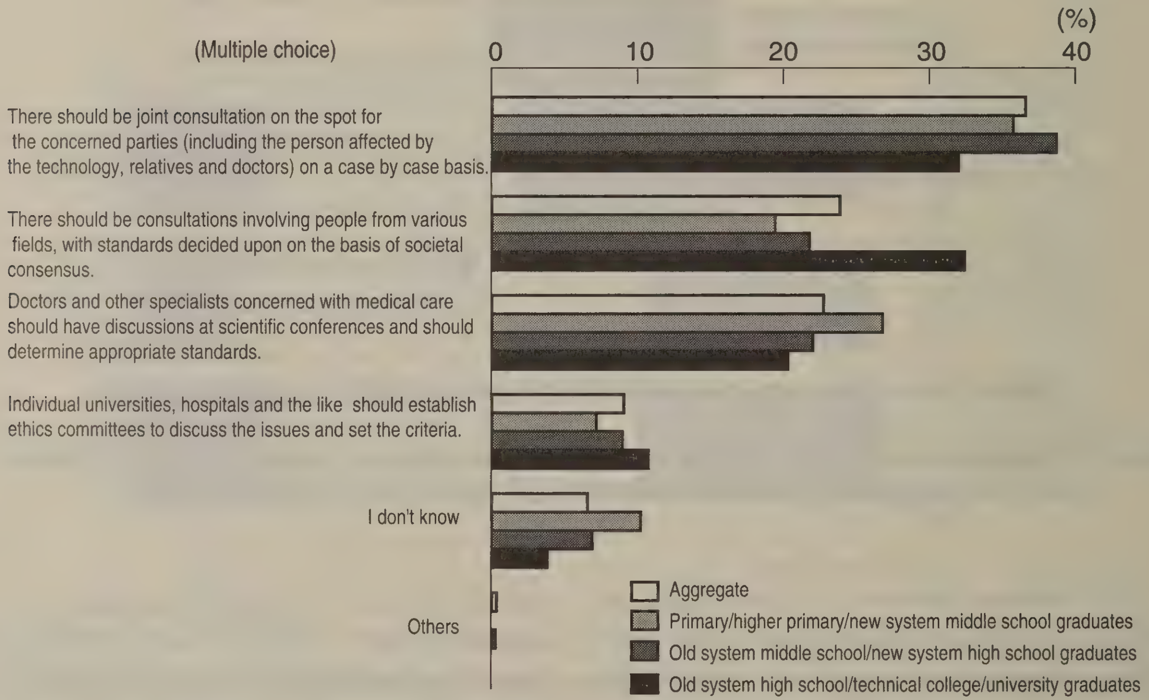


Figure 1-3-19 People's perceptions regarding ethics in high-tech medical technology.

Source: "Report on a Public Opinion Survey concerning Ethics in Medicine," Prime Minister's Office (October 1990 Survey).

1.3.4.2 Promoting Dialogue between Society and Persons Involved in Science and Technology

The lack of interaction and mutual understanding between society and persons involved in science and technology is viewed as one important factor contributing to public dissatisfaction with science and technology. Therefore, constructive interaction should be established between the two by continously providing the public with information it can understand and assessing its reaction to this information.

In responding to complex social issues involving science and technology, it is also important that those involved in science and technology properly understand society's awareness of these fields. At the same time, scientific and technological methodology should be explained to society. This, in turn, is predicated on enhancing the related endeavors and self-awareness of scientists and engineers, and on increasing society's ability to understand science and technology.

1.3.4.2.1 Providing Understandable Information

With respect to the public's knowledge of science and technology, public opinion surveys show that there are many people who consider themselves capable of understanding a scientific or technical matter when explained in an easy-to-understand manner. Furthermore, the percentage of such people is showing a rising tendency (Fig. 1-3-20). On the other hand, in

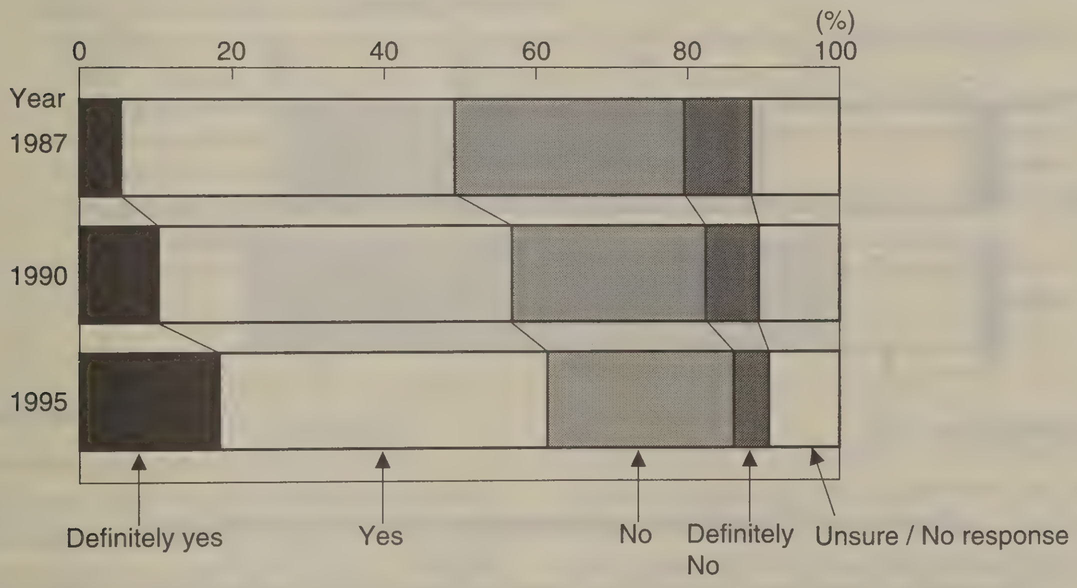


Figure 1-3-20 Understanding scinece and technology. part 1

Note: The question was, "Do you think most people are capable of understanding a scientific or technical matter when explained in an easy-to-understand manner?"

Source: "Public Opinion Servey on Scinece and Technology and Society," Prime Minister's Office.

the same survey, more participants than before answered "No" or "Definitely no" to the question, "Do you think there are enough opportunities to learn what you wish to about science and technology, and enough sources of such information?" (Fig. 1-3-21). People have great feelings of dissatisfaction with the inadequacy of easily understandable information and opportunities to learn about science and technology.

The recognition of the inadequate supply of easily understandable information at the interface between society and science and technology seems to be the cause of dissatisfaction regarding science and technology. Serious efforts to dispel this sort of dissatisfaction are necessary.

1.3.4.2.2 Increasing the Public's Understanding of Science and Technology

Proper understanding is one prerequisite for society's acceptance of science and technology, and this, in turn, necessitates increasing the number of people who consider themselves capable of understanding scientific and technical matters when explained in an easy-to-understand manner. A Person is more inclined to consider himself or herself as this type of person if he or she already likes science (Fig. 1-3-22). Thus, first of all, it is important to get more people to like science so that a greater percentage of the population considers itself capable of understanding scientific and technical matters (when explained in an easy-to-understand manner), thereby improving the general public's un-

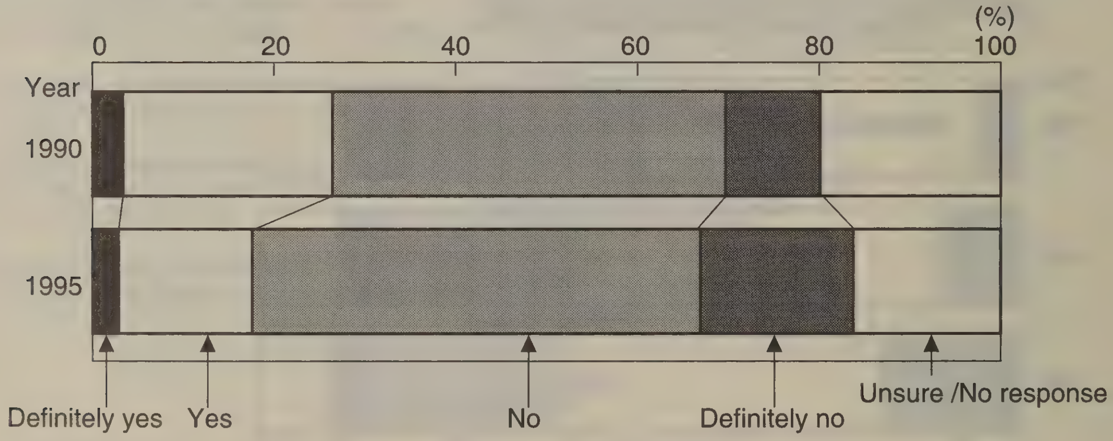


Figure 1-3-21 Opportunities to learn about science and technology.

Note: The question asked was, "Do you think there are enough opportunities to learn what you wish to about science and technology, and enough sources of such information?"

Source: "Public Opinion Survey on Science and Technology and Society," Prime Minister's Office.

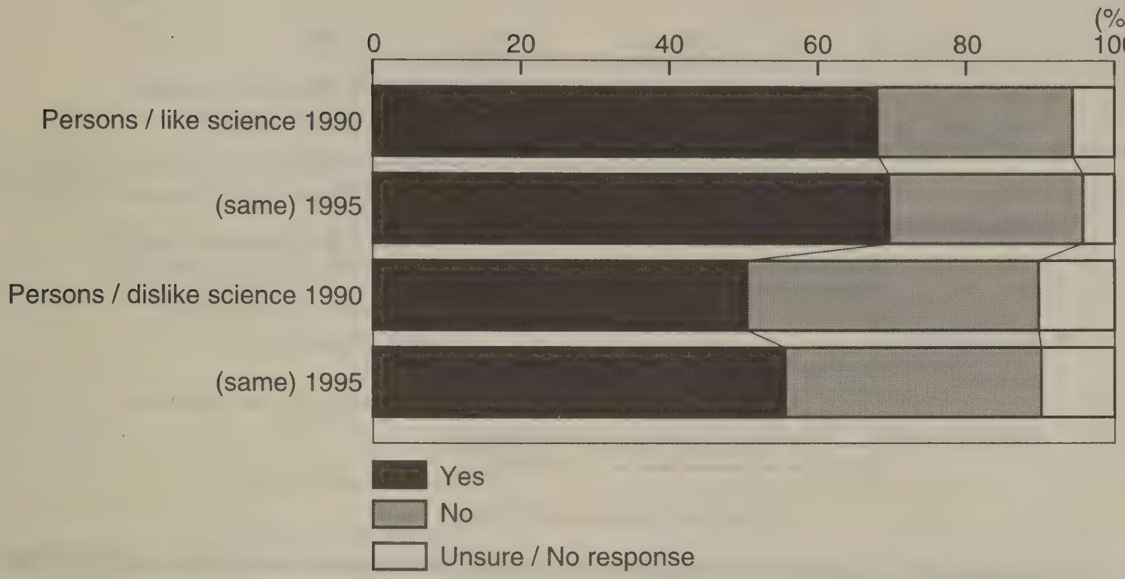


Figure 1-3-22 Understanding science and toechnology. part 2

Notes: Respondents' like or dislike of science was calculated according to their response to the question, "Do you think most people are capable of understanding a scientific or technical matter when explained in an easy-to-understand manner?":

* The figures for "Yes" are the sum of respondents who answered either "Definitely yes" or "Yes".

* The figures for "No" are the sum of respondents who answered either "Definitely no" or "No".

* "Persons who like science" are defined as the sum of respondents who said they either "liked science very much" or "liked science."

* "Persons who dislike science" are defined as the sum of respondents who said they either "disliked science very much" or "disliked science."

Source: "Public Opinion Survey on Science and Technology and Society," Prime Minister's Office.

derstanding of science and technology.

In addition to carrying out measures indicated in the recommendations in Report No. 20 of the Council for Science and Technology, "A Basic Policy for securing Human Resources in the Fields of Science and Technology," it is necessary to work out ways to make science and technology seem more familiar to people.

The most common tendency among people who are favorably inclined toward science is to give a high appraisal of the positive aspects of science and technology (Fig. 1-3-23). A future increase in people who are favorably inclined toward science is linked to an increase in the number of people who appreciate the positive aspects of science and technology. This, in turn, should lead to more confidence in science and technology.

1.3.4.2.3 Responding to Concerns Generated by Scientific and Technological Progress

With respect to addressing concerns generated by scientific and technological progress, according to the results of a survey carried out by the National Institute of Science and

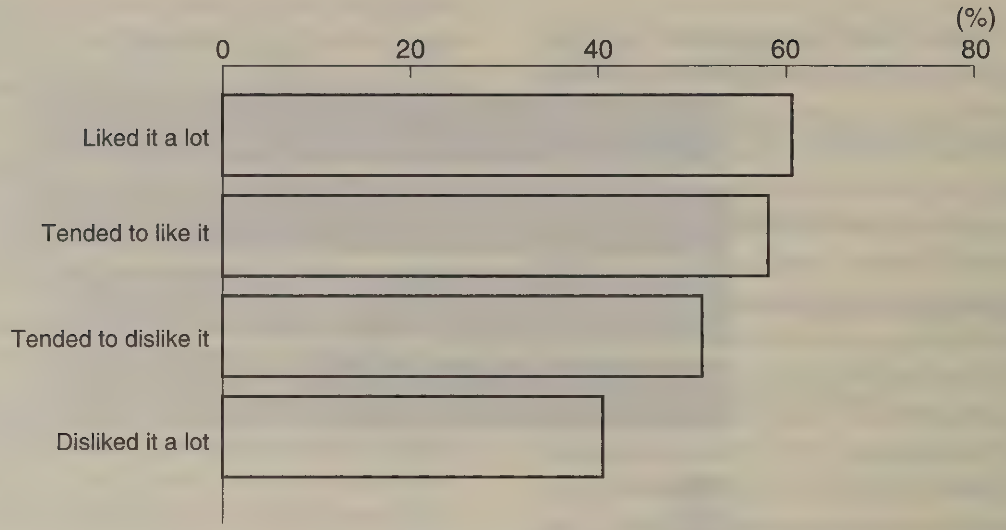


Figure 1-3-23 Appraisals of positive and negative aspects of science and technology and the likes or dislikes regarding science.

Note: Percentages of those who think there are more positive aspects than negative aspects regarding science and technology are shown for the four groups saying they liked science a lot, tended to like it, tended to dislike it and disliked it a lot.

Source: "Public Opinion Survey on Science and Technology and Society," Prime Minister's Office (February 1995).

Technology Policy of the Science and Technology Agency, it is hoped that they will be alleviated by such measures as "thoroughgoing consideration on the part of businesses in developing products," "attention by government to the opinions of specialists in creating policy principles and guiding and regulating business," "constant awareness by scientists and engineers of what they are engaged in" and "an active effort by the mass media to carry out fair and impartial reporting." (Fig. 1-3-24) High-Tech researchers and engineers have indicated that it is important to take appropriate measures to bring about a public understanding and acceptance of new scientific knowledge and technology,through such measures as the "promotion of research on how to harmonize science and technology with humans as well as and society", the "promotion of communications with the public (government public relations reports, scientific journalism, etc.)", the "development of excellent research institutions" and the "creation of an environment in which one can get familiar to science and technology (the establishment of museums, etc.)" (Fig. 1-3-25).

On the basis of these perceptions, it is important to make efforts to move in the directions described below.

1.3.4.2.3.1 Expectations toward Corporate Efforts

As a policy to deal with concerns regarding science and technology, it is desirable for corporations to carry out their activities in ways that meet the public's heightened expectations for product development that ensures safety. The recently enacted Product Liability Law may be cited as a measure to promote this sort of attitude among businesses.

Under the previous system, proof of an error

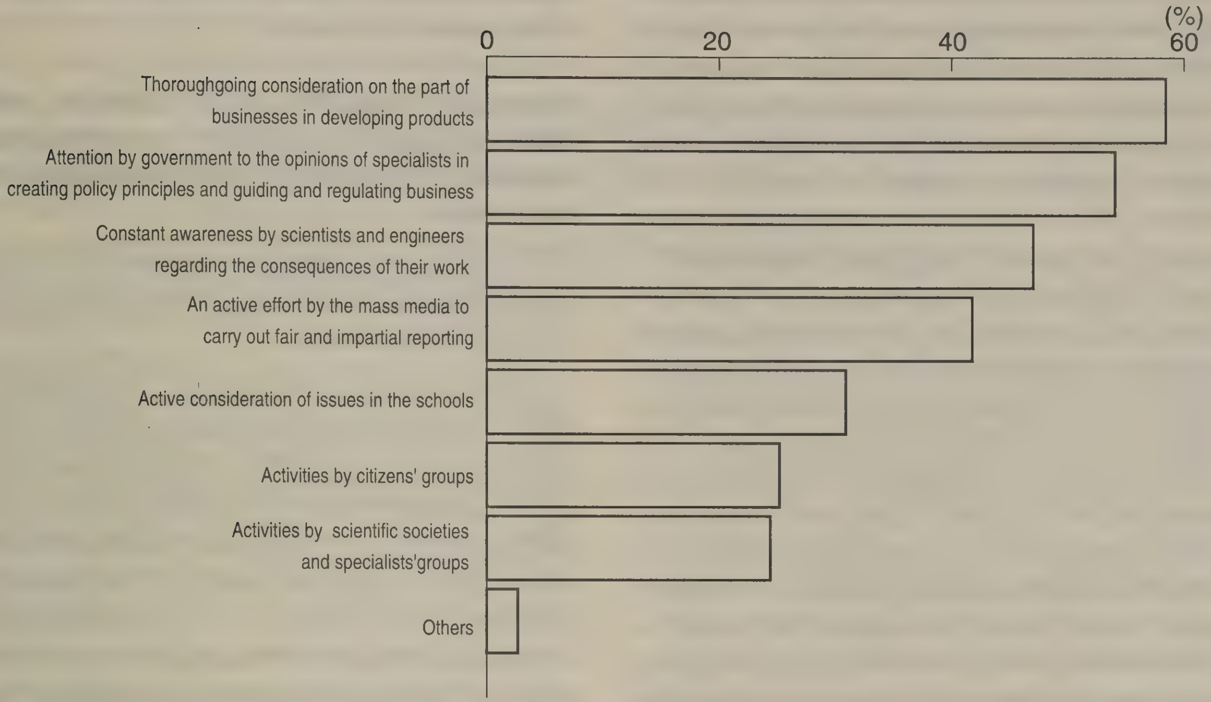


Figure 1-3-24 Measures to deal with concerns regarding science and technology.

Source: "The Influence of Science and Technology on Humans/Society," National Institute of Science and Technology Policy, Science and Technology Agency, March 1994.

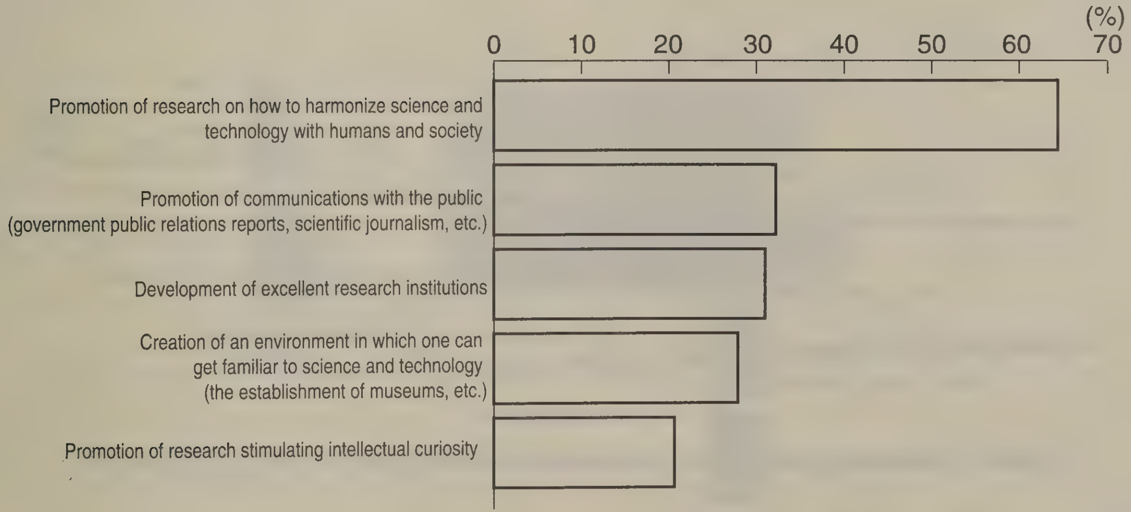


Figure 1-3-25 Perceptions by researchers of appropriate measures to bring about a public understanding and acceptance of new scientific knowledge and technology.

Source: "Survey on High-Tech Researchers and Engineers (FY1990)," Science and Technology Agency.

on the part of the manufacturer was required in order to obtain compensation for any loss or harm. In an era when science and technology are highly advanced the major burden of proof of an error by a manufacturer was placed on the person suffering damage or loss and the chances were that such persons were not adequately protected. The Product Liability Law's "goal is the protection of a person who suffers harm due to a defect in a manufactured product in order to contribute to the sound development of the national economy and the increased stability of people's lives." The rule is that when there is a defect in a manufactured product, the manufacturer and others concerned must provide compensation. A defect is defined as "a lack of normally expected safety in a manufactured product, taking into account the product's characteristics, the way in which it is expected to be used and other conditions including the timing when the product was delivered by the manufacturer." (Product Liability Law, Section 2)

With the enactment of this law, hopefully in the course of developing and manufacturing a commercial product, businesses will try harder than ever before to prevent accidents and give more attention to safety.

1.3.4.2.3.2 Awareness by Scientific and Technological Researchers of the Consequences of Their Work, and Statements to the Public

Many people expect scientific and technological researchers to be more aware of the consequences of their work.

A sense of ethics among researchers is important for the harmonization of science and technology with mankind and society. In response to questions about whether they took ethical issues concerning bioethics,environmental ethics and the like,into account in conducting research more than 80% of researchers took ethics into consideration (fully or to some extent). From this data, it can be said that their ethical consciousness is high overall. In particular over 90% of high-tech researchers specializing in the areas of health and hygiene said they took ethics into consideration . This indicates the high ethical consciousness of such people (Fig. 1-3-26).

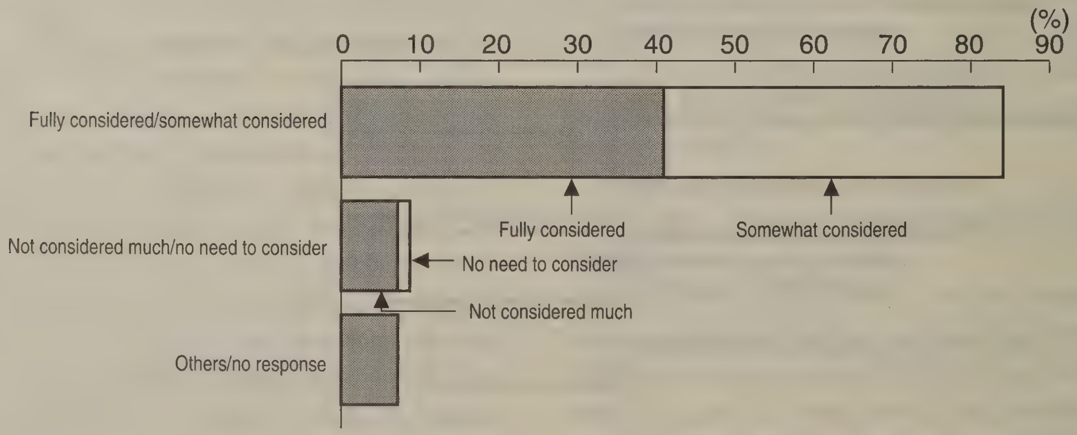


Figure 1-3-26 Ethical perceptions of high-tech researchers and engineers.

Source: "Survey on High-Tech Researchers and Engineers (FY1990)," Science and Technology Agency.

This is, of course, a limited survey of researchers in high-tech areas and does not reflect the situation for all scientists and engineers. Be that as it may, those involved in science and technology, should not only concern themselves with ethics, but also be constantly aware of science and technology's interrelation with people and society. Further, they should continue searching for ways to assure harmony between science and technology and the public and society.

Recently, in particular, there has been a tendency for a growing number of people to think that scientists are indifferent to the people and society. It is to be hoped that scientists and engineers will take this public perception fully into consideration when carrying out their work (Fig. 1-3-27).

In order for persons involved in science and technology to be constantly aware of their interrelation with the public and society, they should possess not merely extensive specialized knowledge, but also a basic interest in a wide range of fields, including verious human and social phenomena. To encourage this, the tendency of society to accept a disinterest in the public and society among scienctists and engineers should be addressed, and conversely, a disinterest in science aechnology amoung non-technical people.

Scientists and engineers should not simply discuss scientific and technological issues which may have a great influence on society just among themselves, but should make their opinions public. The public, in turn, should give accurate and appropriate responses to these opinions so that a constructive dialogue develops between scientists, engineers and society, in general. It is important for scientists and engineers to ensure that their activities are supported by the public and it is also important for them to make an effort to actively make their opinions public. It is also important for the public to respond accurately and appropriately to these opinions made by scientists and engineers.

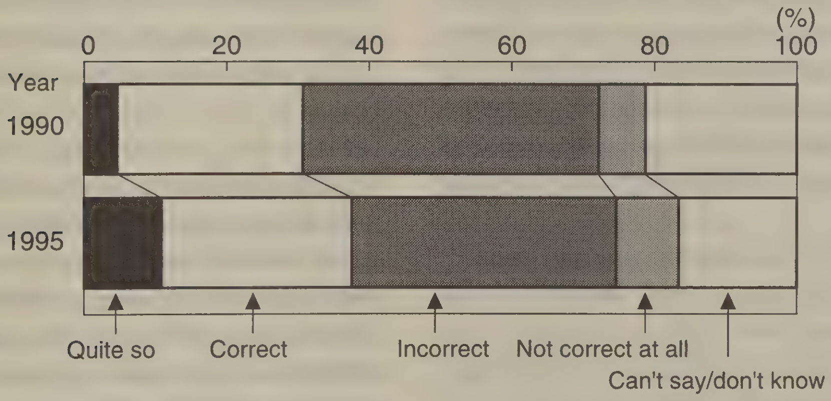


Figure 1-3-27 Public perceptions of scientists' interest in humans and society.

Note: The question asked was, "Is it true that many scientists are indifferent to the public or society?"
Source: "Public Opinion Survey on Science and Technology and Society," Prime Minister's Office.

1.3.4.2.3.3 Expectations toward the Mass Media

The greatest hopes should be placed on the mass media in terms of its ability to effectively transmit information coming from the fields of science and technology to the people as a whole. The mass media has already played a major role in presenting issues related to science and technology to the public and in developing an awareness of the issues. It is to be hoped that they will continue to play an active role in the future in providing a link between scientific and technological activities and the general public.

The role of the mass media is also important in conveying the society's concern to those engaged in science and technology. Its role will grow more important in the future in promoting a dialogue between science and technology and society and serving as a link between the public and those involved in science and technology.

1.3.4.2.3.4 Dealing with the Specialization and Subdivision of Science and Technology

The development of scientific and technological work is not just a matter of moving forward with science and technology, but involves thinking that this is for the sake of mankind and society. It is important to strive for harmony between science and technology and mankind and society through a deepening understanding of humans.

As part of this effort, it is important to keep in mind that many people are concerned over the specialization and subdivision of science and technology and the fact that they can no longer understand these things. There should be encouragement of interchanges among different areas to integrate the subdivided and specialized science and technology and efforts to promote linkage and cooperation between the humanities and social sciences and natural sciences. Efforts are getting underway to set up interdisciplinary projects, science and technology forums and other such means to promote the interchange of researchers in different fields. It is good for scientists and engineers to avoid staying within the narrow confines of their own research to remain constantly aware of society and other people and to maintain a wide range of interests outside their own specialties while pursuing their own research.

1.3.4.2.4 Sharing the Joy of Discovery with Society

Efforts to share with society the moving experiences and intellectual wealth of science and technology are also needed to enable the public to experience science and technology firsthand.

Scientific and technological research is valuable in and of itself and is, therefore, an important human activity. The joy of discovery is also a moving, captivating experience. Thus, images of meteors impacting on Jupiter, pictures of planets transmitted by probes exploring the far reaches of space, and, say, video footage of marine life in ocean depths where no such life was thought to exist all have the power to enthrall and fascinate the public. Thus, in addition to actual research to broaden our understanding of nature, efforts should also be made to strive to inform the public of progress that is made, and to share with society the joy of new knowledge and the moving experiences taht are a part of research.

From this perspective, it is important for people engaged in science and technology to take an active and continuous part in telling the public about their dreams and stories related to science and technology. There should also be increased opportunities for people to become familiar with the latest results of research activity. Great results can be expected from the prospect of people working at the cutting edge of science and technology having a direct dialogue with the general public, including young people. There is a growing tendency for people to want to listen to what scientists and engineers have to say and this can serve as a basis for the public acceptance of information provided by them (Fig. 1-3-28). The idea of having research-

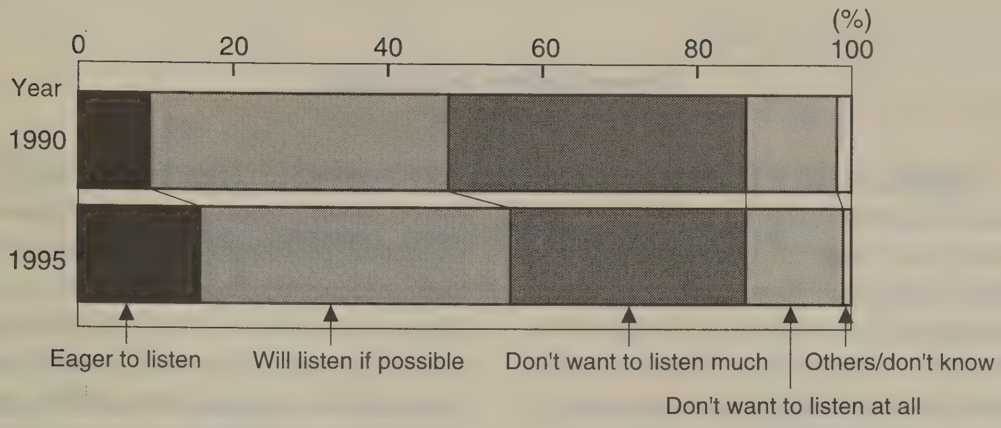


Figure 1-3-28 Interest in what scientists and engineers have to say.

Note: The question asked was, "Do you want to listen to what scientists and engineers have to say?"
Source: "Public Opinion Survey on Science and Technology and Society," Prime Minister's Office.

ers from Tsukuba Science City go and visit the schools they graduated from and speak about their own experiences was tried out during Science and Technology Week in FY1995. There have also been unique experiments in the form of research display areas where researchers can carry on their own work, while at the same time making the very latest experimental results known to the general public in an easily understandable manner. Activities like these should be continued in the future.

Furthermore, today's economic wealth notwithstanding, such fascination and captivation still have the power to inspire young people and stimulate their imagination, and can therefore be a driving force behind efforts to revitalize scientific and technological activity and attract people to it. Consequently, the public's contact with nature should be increased. More participatory and experience-oriented science museums should be built. More opportunities to come into contact with and experience science and technology should be provided with each segment of society. Through these efforts, young people can experience not just the joy of discovery, but also the joy of firsthand experience and of creation.

Sharing the intellectual wealth and moving experiences of science and technology and enabling young people to feel the joy of creation and the joy of firsthand experience is an important part of making science and technology a more perceptible part of their lives, and further efforts in this area are called for. Such persistent efforts should help relieve the certain tension that exists between society and science and technology, and thus are essential to an age in which science and technology are being called on to play an even larger role than before in assuring individual welfare.

Concluding Remarks

The most important resource available to Japan at War's end was the capabilities and knowledge of the people handed down to them by their ancestors. The profound changes of the postwar era also affected science and technology, resulting in the redistribution and repositioning of human and material resources. In the following years, through diligent efforts and with the wisdom of her people, Japan overcame her difficulties and faced the issues of the era head-on, eventually acheving today's prosperity. The road was by no means an easy one, but instead required the nation to confront various difficulties, search tenaciously for solutions, and strive relentlessly towards her goals.

During the fifty years of the postwar period, science and technology have played a major role in economic growth and have been a driving force behind today's affluent life styles. Japan took basic technology and, by improving and enhancing it in original ways, has come to produce the world's highest quality products. Japan has not, however, been completely successful at creating the knowledge and technology needed to develop new, original products, and today, with the economies of the industrialized nations reaching maturity as the NIEs and developing nations grow economically, it is now important that Japan should find new breakthroughs and create new markets. Thus, the need for Japan to call forth its creativity is greater than ever before. In the area of science and technology, this means taking the neccessary steps to hand down its intellectual reources to the next generation, while simultaneously maximizing its originality and actively implementing the institutional reform needed to apply it to the creation of new markets.

Realizing individual welfare necessitates using science and technology to maintain and improve health, improve the conditions of daily existence, bolster the socioeconomic infrastructure, and secure the public's safety (indluding disaster prevention) in accordance with the public's demands and with an emphasis on daily lives. But Japan is being called on to use its science and technolog not only to achieve individual welfare for the Japanese people, but also to enhance the welfare of human society.

At the same time, however, there are concerns that a certain tension is growing between science and technology on the one hand and people and society on the other. Those involved in science and technology, in order to relieve this tension, shoud be constantly aware of science and technology's interrelation with people and society and strive to find ways to ensure harmony between both sides. Dialogue between the public and those involved in science and technology is also important in assuring the social acceptance of the fruits of scientific and technological endeavor.

Japan, in order to ensure its continued development through the next half-century, should build on and make further use of its most important resource, the capabilities of its people. With constant awareness of science and technology's interrelation with society, and of the fact that the original objective of science and technology is to increase welfare for all people, Japan should strive for continuous reform and for increased investment in science and technology in order to create science and technology which produces new value and truly pleasant lives for the Japanese people.

Part 2

The Current Status of Science and Technology in Japan and Other Nations

The leading advanced nations reacted to the changing conditions brought about by the ending of the Cold War by attaching importance to economic growth, strengthening of their competitiveness, and providing employment. Noteworthy among these countries are those that have strengthened their competitiveness through the advancement of their science and technology. In particular, the advanced countries are dealing with mounting anxiety over the penetration of their global markets coupled with high unemployment at home by promoting innovations in science and technology and striving to foster new industries. These countries are feeling the need to plan economic expansion and secure employment through more active development of science and technology policies.

Until recently, Japan's science and technology activities have enjoyed steady growth due to healthy private investment in research and development (R&D). However, due to the slackening economy, corporate R&D expenditures showed consecutive decreases in FY1992 and FY1993, and in FY1993, overall R&D expenditures for the country as a whole recorded a decrease for the first time since the survey was initiated. It is thought that in order for Japan to continue in improving the standard of living of its people and achieve stable economic growth, it should further strengthen the R&D activities which have been the basis of its prosperity so far.

Part 2 will compared Japan and major countries in the areas pertaining to science and technology, such as research expenditures and number of researchers, so as to highlight the special characteristics of Japan's science and technology activities. This information will then be used for a more in-depth analysis of the trends in Japan's research activities[1].

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[1] In this paper, "research activities" apply only to natural sciences and not to humanities and social sciences. Cases which involve humanities or social sciences will be annotated. Classification of natural sciences as distinct from social sciences and humanities is based on the individual research institute or university and college department concerned.

2.1 R&D Expenditures

2.1.1 Total R&D Expenditures

2.1.1.1 Trends in R&D Expenditures

When a country examines its R&D expenditures[2], its contents and approach may differ from other nations. As a result, a simple comparison of R&D expenditures among countries may not present compatible data, although it gives a general idea as to a country's attitude toward science and technology. In terms of R&D expenditures, the United States spends the most followed by Japan and Germany[3] (Figure 2-1-1).

2.1.1.2 Increase of R&D Expenditures in Real Terms

R&D expenditures in real terms for Japan, the United States, Germany, France and the United Kingdom are calculated using the amount in 1990 as the basis of comparison. According to this data, Japan had the highest growth rate among these nations until a few years ago, but in FY1992 this growth tapered, and in FY1993, a

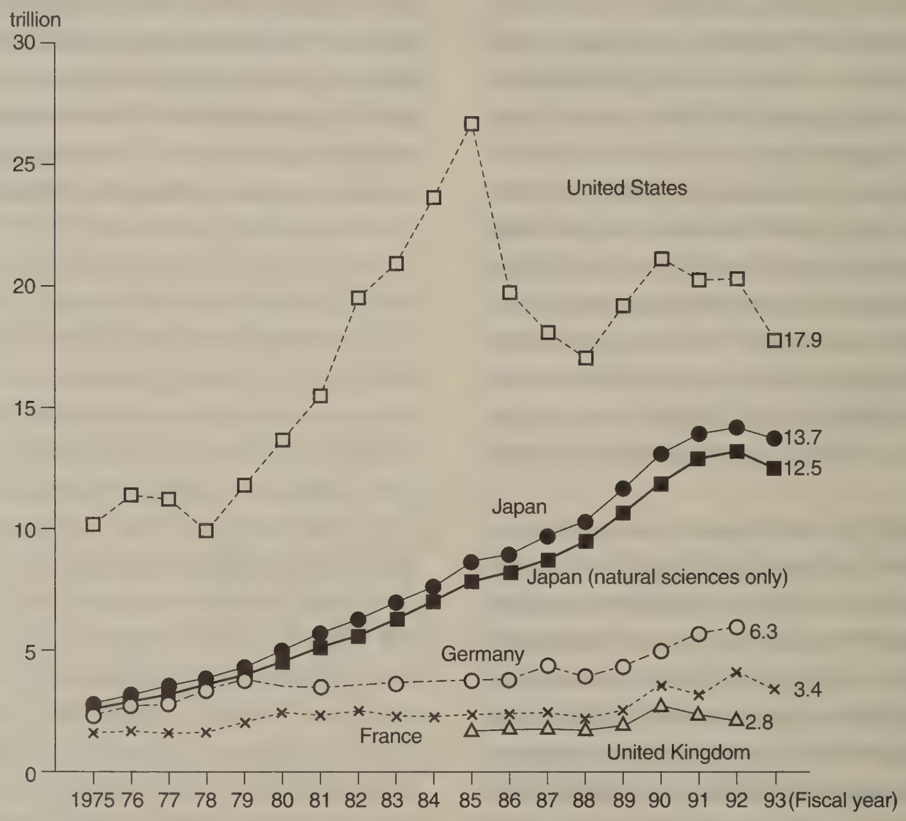

Figure 2-1-1(1) Trends in R&D expenditures of selected countries - IMF exchange rate conversion

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[2] R&D expenditures are the funds spent by research institutions themselves for research. There are two methods of estimating R&D expenditures: disbursement and cost. This paper considers R&D expenditures to be disbursements. Disbursement includes expenditures on labor, materials, tangible fixed assets, and so on. In case of cost, it is computed by adding the depreciation of tangible fixed asset, instead of expenditure on the tangible fixed assets. Japanese R&D expenditures are calculated for Japan's fiscal year, which begins in April.

[3] The data for Germany in Chapter 1 and 2 cover Western Germany only, until 1990, and Unified Germany from 1991.

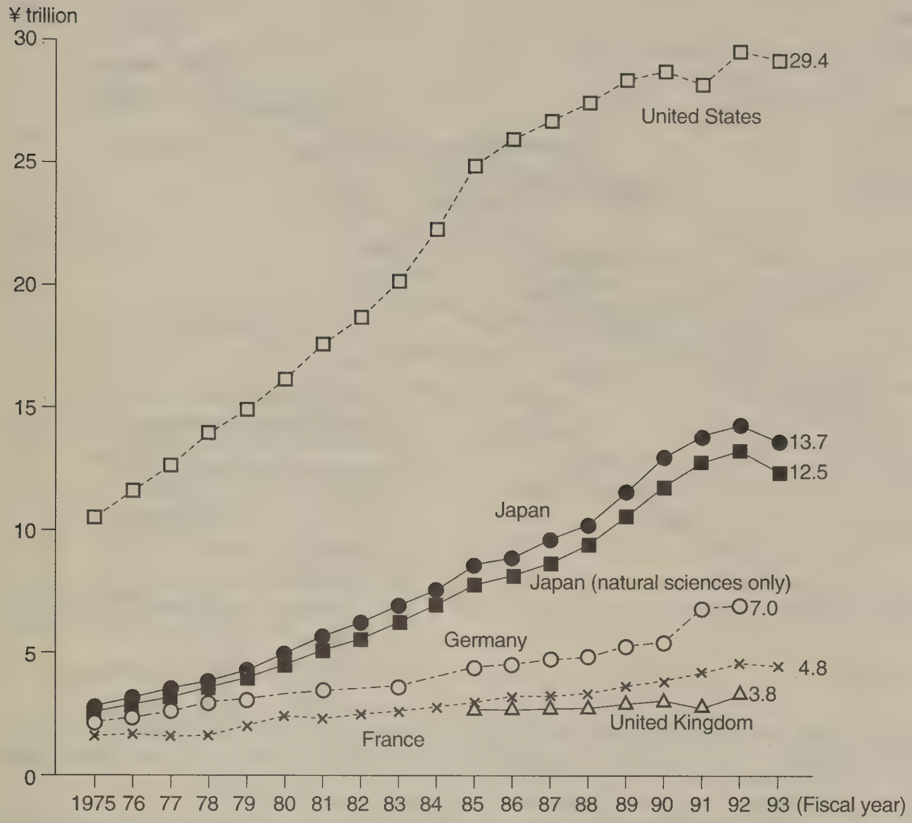
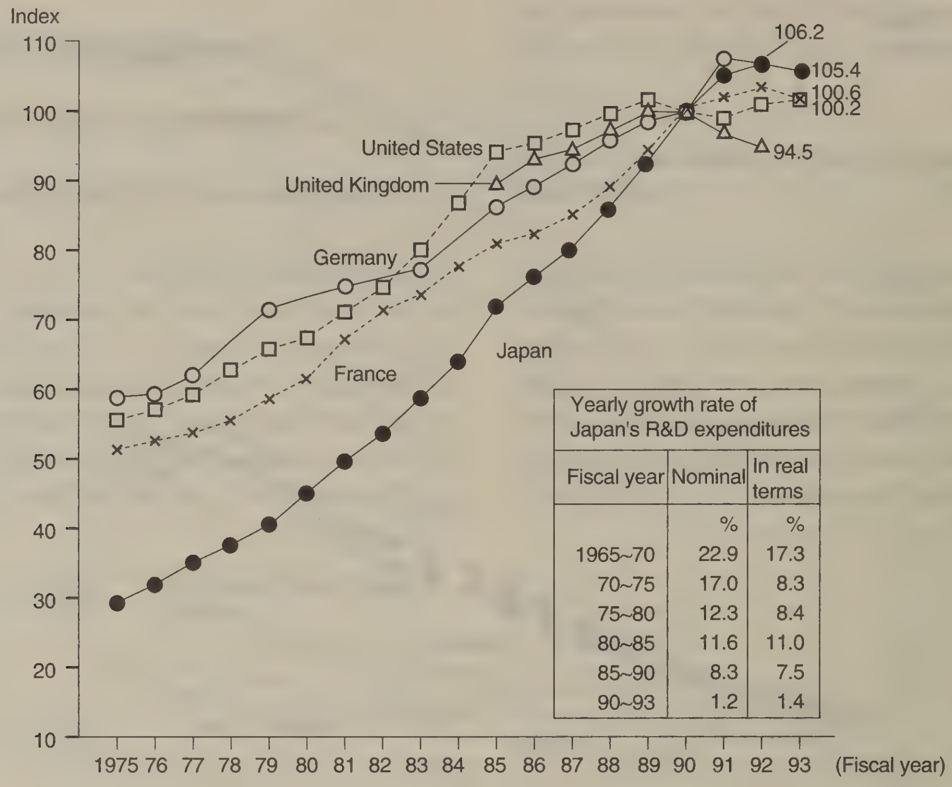


Figure 2-1-1(2) Trends in R&D expenditures of selected countries - OECD purchasing power parity

Notes: 1. For comparison, statistics for all countries include research in social science and humanities. The figure for Japan shows also the amount for natural sciences only.
2. The 1992 data for the US are provisional and the 1993 data are estimates.
3. Germany: The data from 1990 are provisional. The years for which data are not available are indicated on a straight line.
4. The 1993 data for France are provisional.

Sources: Japan — "Report on Survey of Research and Development" by Statistics Bureau, Management and Coordination Agency.
United States — "Science & Engineering Indicators 1993" by National Science Board.
Germany — "Bundesbericht Forschung", "Faktenbericht zum Bundesbericht Forschung" by Federal Ministry for Research and Technology (BMFT)
France — Projet de Loi de Finance — Rapport annexe sur l' Etat de la Recherche et du Developpement Technologique.
United Kingdom — "Forward Look 1994" by Office of Science and Technology

(See Appendix 1)



Yearly growth rate of Japan's R&D expenditures		
Fiscal year	Nominal	In real terms
	%	%
1965~70	22.9	17.3
70~75	17.0	8.3
75~80	12.3	8.4
80~85	11.6	11.0
85~90	8.3	7.5
90~93	1.2	1.4

Figure 2-1-2 Growth of R&D expenditures (in real terms) in selected countries

Notes: 1. For comparison, statistics for all countries include research in social sciences and humanities. The figures for Japan show also the amount for natural sciences only.
2. The index in 1990 is set at 100.
3. The 1992 data for the US are provisional, the 1993 data are estimates.
4. Germany: The data from 1990 are provisional. The years for which data are not available are indicated on a straight line.
5. The 1993 data for France are provisional.

Source: Same as in Figure 2-1-1.
(See Appendix 1,15)

decrease from the previous year was experienced for the first time since the survey was initiated. (Figure 2-1-2).

2.1.1.3 R&D Expenditures as a Percentage of Gross National Product (GNP)

R&D expenditures as a percentage of GNP show the level of research investment. During the 1970s, this percentage decreased or remained level in major countries. It began to increase in 1978, but, has decreased or remained level in major countries in recent years. R&D expenditures in Japan grew steadily until FY 1990, remained level in 1991. Although this was followed by decreases in FY1992 and FY1993 due to decreases in private R&D expenditures, Japan has maintained its position among the leading countries. (Figure 2-1-3).

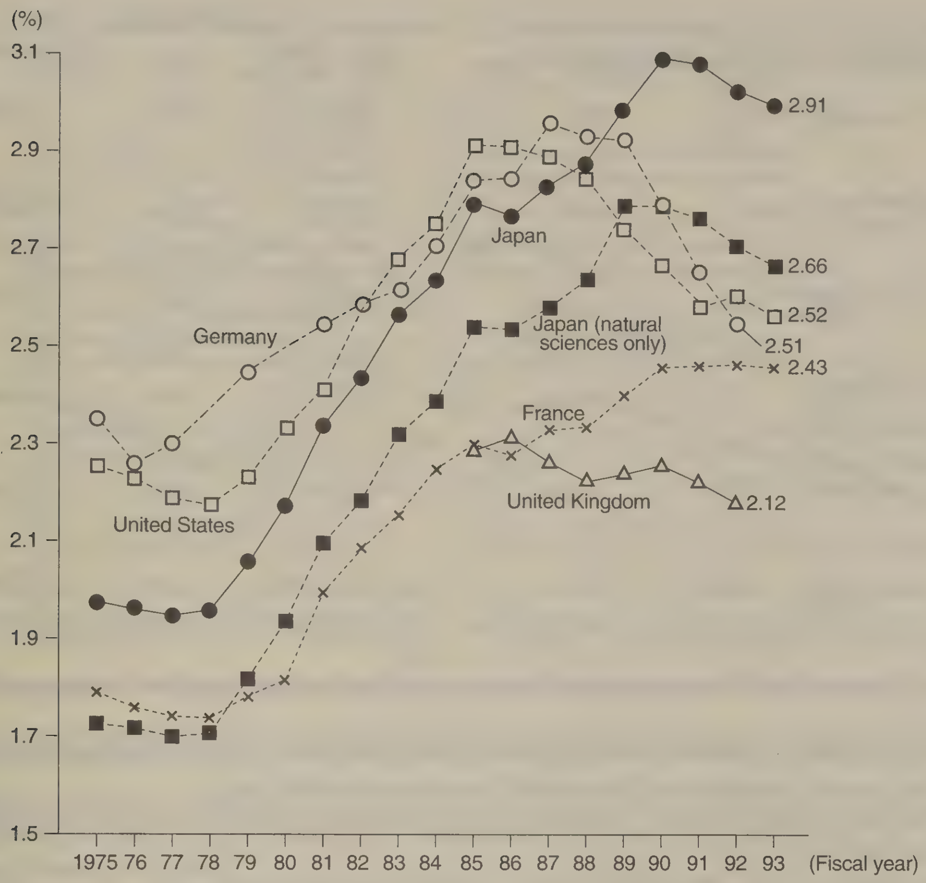


Figure 2-1-3 Growth of R&D expenditures (in real terms) in selected countries

Notes: 1. For comparison, statistics for all countries include research in social sciences and humanities. The figures for Japan show also the amount for natural sciences only.
2. The 1992 data for the US are provisional and the 1993 data are estimates.
3. Germany: The data from 1990 are provisional. The years for which data are not available are indicated on a straight line.
4. The 1993 data for France are provisional.

Source: Same as in Figure 2-1-1.
(See Appendix 1)

2.1.2 R&D Expenditures by Financing and Performance Sector

2.1.2.1 Share of R&D Expenditures by Financing and Performance

R&D expenditures can be characterized by the financing and performance aspects of categorized sectors. The statistics compiled by the Organization for Economic Cooperation and Development (OECD) categorize sectors into

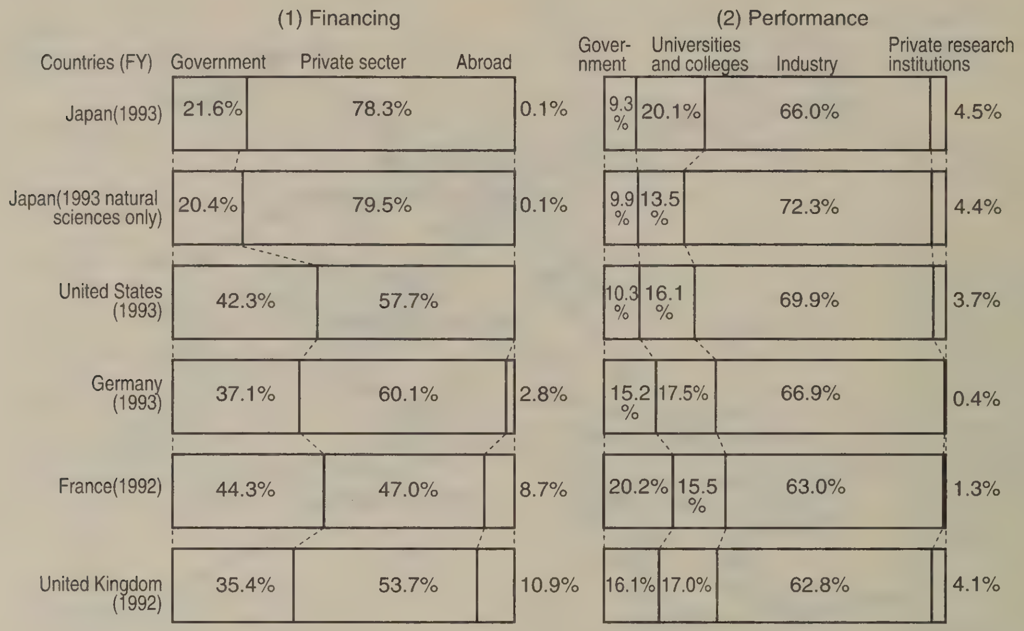


Figure 2-1-4 Share of R&D expenditures financing and performance sector in selected countries

Notes: 1. For comparison, statistics for all countries include research in social sciences and humanities. The figure for Japan shows the amount for natural sciences only.
2. (1) In the financing column, the private sector includes any sector other than the government and abroad.
3. The figures for the United States and for Germany are estimates.

Sources: Japan, United States and United Kingdom — Same as in Figure 2-1-1.
Germany and France — OECD statistics.
(See Appendix 1,2)

government[4], industry, universities and colleges, private research institutions,and abroad. Shares of R&D expenditures by financing and performance in selected countries are compared by OECD - categorized sectors.

The government R&D expenditures percentage may differ from country to country due to differences in defense-related research, tax structure, activities in the private sector, etc. Generally speaking, in terms of the government share of R&D expenditures, France is ranked first at 44.3%, followed by the United States at 42.3%, Germany at 37.1% and the United Kingdom at 35.4%. Including social sciences and humanities, Japan's share is a mere 21.6%. In Japan, the private sector finances a great deal of R&D expenditures (Figure 2-1-4(l)).

Looking at R&D performance, industry spends approximately two-thirds of the total R&D expenditures in selected countries. This means that private companies play a big role in performing R&D. The government research institutions' share of R&D performance is at 20.2% in France which is a higher ratio than in other selected countries (Figure 2-1-4(2)).

In the past, fluctuations in the proportion of

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[4] In Chapters 1 and 2, when research expenses and number of researchers are expressed, "governments" means central governments and local governments (in the case of Japan, local public bodies).

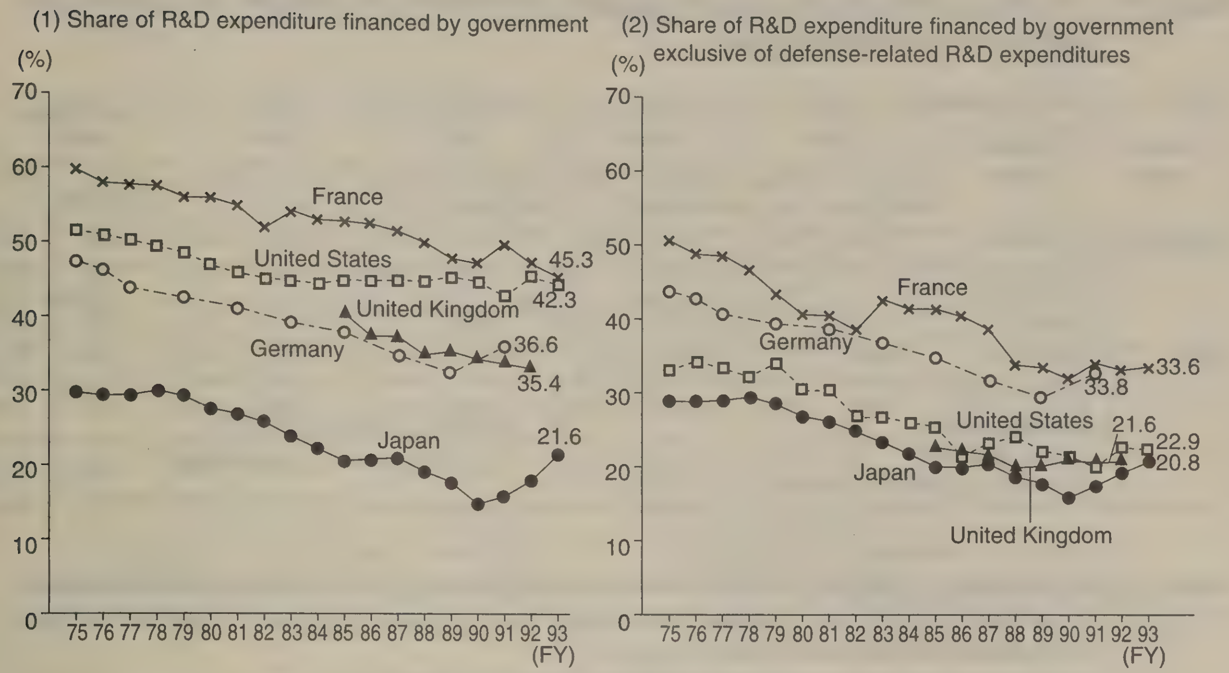

Figure 2-1-5 Trends in government-financed for R&D expenditures in selected countries

Notes: 1. For comparison, statistics for all countries include research in social sciences and humanities.
2. Government percentages exclusive of defense-related research expenditures are calculated by the following equation.

$$\frac{\text{(Government financed R\&D expenditures)} - \text{(Defense-related R\&D expenditures)}}{\text{(R\&D expenditures)} - \text{(Defense-related R\&D expenditures)}} \times 100\ (\%)$$

3. The 1992 data for the U.S. are provisional and the 1993 data are estimates.
4. Germany: The data from 1990 are provisional. The years for which data are not available are indicated on a straight line.
5. The 1993 data for France are provisional.

Sources: Japan, the United Kingdom, Germany and France — same as in Figure 2-1-1.
"Annual Review of Government Funded R&D" by the Cabinet Office.
(See Appendix 1)

government burden showed a gradual downward trend for each country, but in recent years an upward trend can be seen in Japan as well as other countries. This is thought to be because each national government has stepped up investment in R&D during conditions of economic slackening in which private sector research expenses show faltering growth. Excluding the defense-related R&D budget including social sciences and humanities, the government shares of R&D financing were 33.8% in Germany, 33.6% in France, 22.9% in the United States and 21.6% in the United Kingdom. In contrast, the Japanese government's share topped 20% in FY1993 for the first time in six years, at 20.8%. (Figure 2-1-5).

Comparing flows of R&D expenditures between financing and performance sectors shows that in Japan there is a lesser flow of R&D expenditures between sectors (government, industry, universities and colleges) than exists in other countries and that in the Unites States the ratio of industry R&D expenditure funded by government is greatest (Table 2-1-6).

Table 2-1-6 The flows of R&D funds between industry, universities and colleges, and government sectors in selected countries

Financing sector	Performing sector	Japan (1993FY)		United States (1993FY)		Germany (1991FY)		France (1990FY)		United Kingdom (1992FY)	
		Amount unit. ¥100mill	Share %	Amount unit. ¥100mill	Share %	Amount unit. ¥100mill	Share %	Amount unit. ¥100mill	Share %	Amount unit. ¥100mill	Share %
Government	Government	12,468	97.5	31,042	100.0	9,972	95.5	10,435	93.1	5,224	84.8
	Government	316	2.5	0	0	*352	3.4	423	3.8	627	10.2
	Industry	1,273	1.4	52,921	25.2	5,045	10.8	5,536	19.8	3,315	13.4
Industry	Industry	89,038	98.3	152,031	74.2	40,253	85.8	19,349	69.1	17,120	71.2
	Universities and colleges	13,972	50.6	31,229	64.6	9,926	92.3	6,278	92.9	4,557	70.2
	Universities and colleges	671	2.4	2,805	5.8	823	7.7	328	4.9	500	7.7

Notes: 1. For comparison, statistics for all countries include research in social sciences and humanities.
2. Percentages show the share of the R&D expenditures of financing by sector against the total R&D expenditures of performance by sector.
3. The amounts are converted based on OECD purchase power parity.
4. The U.S. data are estimates.
5. The "goverment" portion of the performing sector and the * portion of the financing sector for Germany include private research facilities.

Sources: Japan, The U.S., Germany and the U. K. — Same as in Figure 2-1-1.
France — OECD statistics.
(See Appendix 2)

In Japan, industry performs little of government- financed R&D. This is because, in Japan, each sector has been rather independent from one another, and has had little interaction. Furthermore, Japan's private sector is quite active in R&D. Another reason is, for example, in the United States, the flow of defense-related R&D expenditures between sectors is very high.

2.1.2.2 R&D Expenditures by Sector

R&D expenditures are increasing in major countries. Examining the growth rate in R&D expenditures in real terms to see which sector is contributing most, we see that university, government and private research institutes showed no or only slight increase, while the industrial sector, with the exception of United States, has the significant growth rate. This proves that R&D activities by the industrial sector have been increasing in recent years. The rate of increase is especially high in Japan (Figure 2-1-7).

Industry has a great influence on growth of R&D expenditures. Particularly in Japan, the growth of R&D expenditures has been influenced by trends in R&D expenditures by companies. Examining changes in the contribution by sectors to the annual increases of Japan's R&D expenditures in real terms, R&D expenditures in the industrial sector increased greatly during the period of heavy growth in the late 1960s, and Japan's total R&D expenditures increased sharply. However, R&D expenditures by industry began stagnating in the early 1970s, and caused Japan's total R&D expenditures total compared to the previous year also dropped.

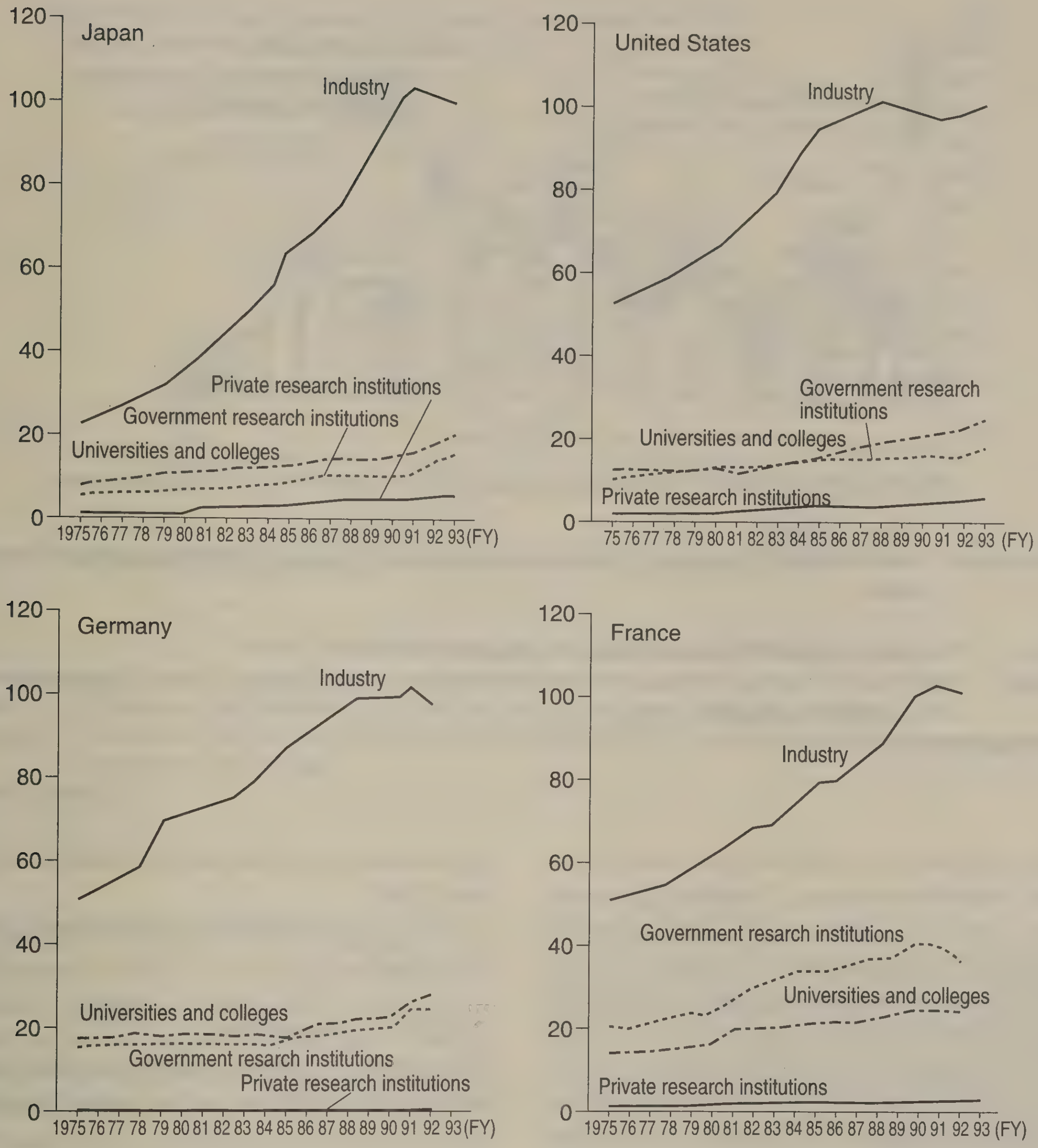

Figure 2-1-7 R&D expenditure growth (in real terms) by sector in selected countries

Notes:
1. The index in 1990 is set at 100 in each country. This is equivalent to R&D expenditures (in real terms) by industry in that year.
2. All countries except Japan include social sciences and humanities.
3. The 1992 data for the U.S. are provisional and the 1993 data are estimates.
4. Germany: The 1988 data and the data from 1990 are estimates. The years for which data are not available are indicated by a straight line.
5. The 1993 data for France are provisional.

Sources: Japan, the U.S. — Same as in Figure 2-1-1.
Germany and France — OECD statistics.

(See Appendix 15)

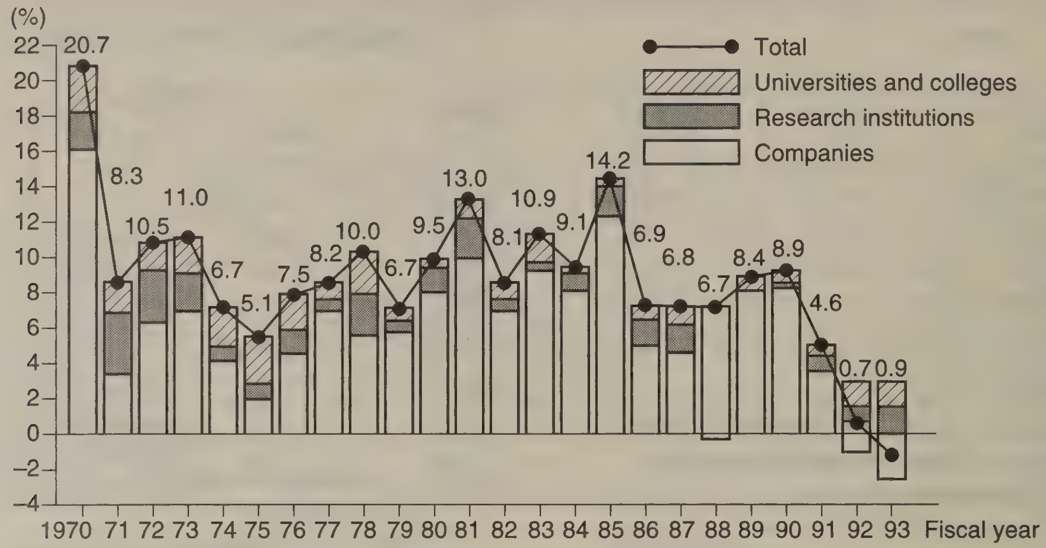

Figure 2-1-8 Contributions by sectors to the annual increases of Japan's R&D expenditures in real terms

Note: The deflation raterring for each sector is based on FY1990.
Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 5,15)

From the late 1970s, R&D expenditures by industry started to increase. Excluding the recession years of FY 1986 and FY 1987, generally high growth was maintained. Later, in FY 1991, when the recession process began, research expense growth rates in industrial circles slowed. R&D expenditures by industry decreased in both FY1992 and FY1993. These were accompanied by a drop in FY1993 from the pervious year in overall national R&D expenditures. (Figure 2-1-8).

This section gives R&D expenditures in Japan by sector[5].

2.1.2.2.1 Companies

In Japan, 12,200 companies conducted R&D activities in FY1993 according to the "Report on

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[5] Research activities in Japan in this paper are provided by companies, research institutions, and universities and colleges. These classifications are based on the "Report on the Survey of Research and Development" compiled by the Statistics Bureau, Management, and Coordination Agency. The Following defines some of these organizations.

- Companies–Corporate companies (Capital: 1 million yen or more (FY1974 or before), Capital: 300 million yen or more (between FY1975 and FY1978), Capital: 5 million yen or more (FY1979 or after), and profit-oriented public corporations (such as NHK (the Japan Broadcasting Corporation), and the Japan Highway Public Corporation).
- Research institutions-National, local government-owned and private (such as foundations) research institutions and research corporations. Research-centered public corporations are, for example, the National Space Development Agency of Japan, the Power Reactor and Nuclear Fuel Development Corporation, the Japan Atomic Research Energy Institute, and the Institute of Physical and Chemical Research. According to the OECD definition, government research institutions include national and local government- owned research institutions and research-centered corporations.
- Universities and colleges-departments of universities and colleges (including graduate schools), junior colleges, colleges of technology, research institutions attached to the universities and colleges and inter-university research institutes, national institution for academic degrees and Center for National University Finance.

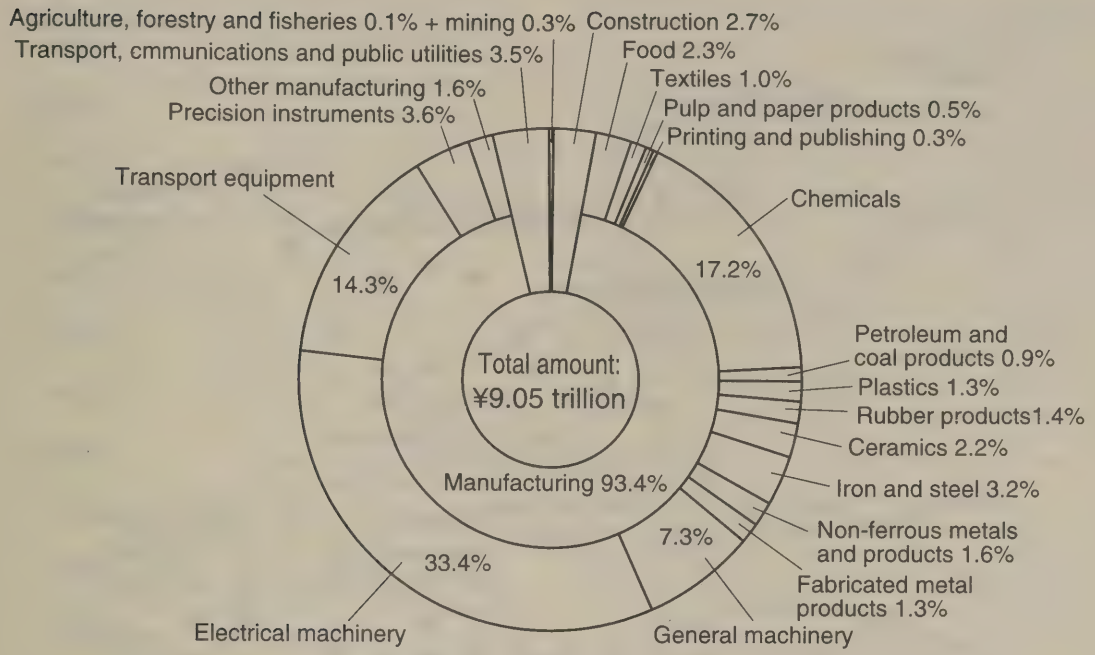

Figure 2-1-9 R&D expenditures by industry (FY1993)

Note: Figures are their shares in percentages to total companies R&D expenditures.
Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 9)

the Survey of Research and Development" by the Statistic Bureau, Management and Coordination Agency. Among them, 95.0% are manufacturing companies; 4.0% are in construction. Among the manufacturing companies, the general machinery industry with 18.3%, the electrical machinery industry with 15.9%, and the chemical industry with 12.8% contain the largest shares.

R&D expenditures by companies have been increasing rapidly; their average annual rate has been 3.9% in real terms for the 5 years from FY1988 to FY1993. FY1993 saw a drop of 5.3% (in real terms, 4.2%) to 9,053.6 billion yen and continued for a second consecutive year in FY1993. However, the proportion of the overall national research expenses was still very large, at 72.3%.

R&D expenditures by industry type show manufacturing at 93.4% followed by transportation/communication/public utilities companies at 3.5%. In the manufacturing category, the electric machinery industry accounts for 33.4%, chemicals for 17.2% and the transport equipment for 14.3% of the total industrial R&D expenditures. These three types of industries perform 64.9% of the total industrial R&D expenditures (Figure 2-1-9). The average annual rates of increase between FY1988 and FY1993 in these three industry sectors were 4.3% (4.0% in real terms) in electrical machinery, 5.6% (4.8%) in chemicals, and 3.6% (2.8%) in transport equipment.

Adopting the ratio of R&D expenditures to total sales as the index that indicates a company's awareness of the importance of R&D, although

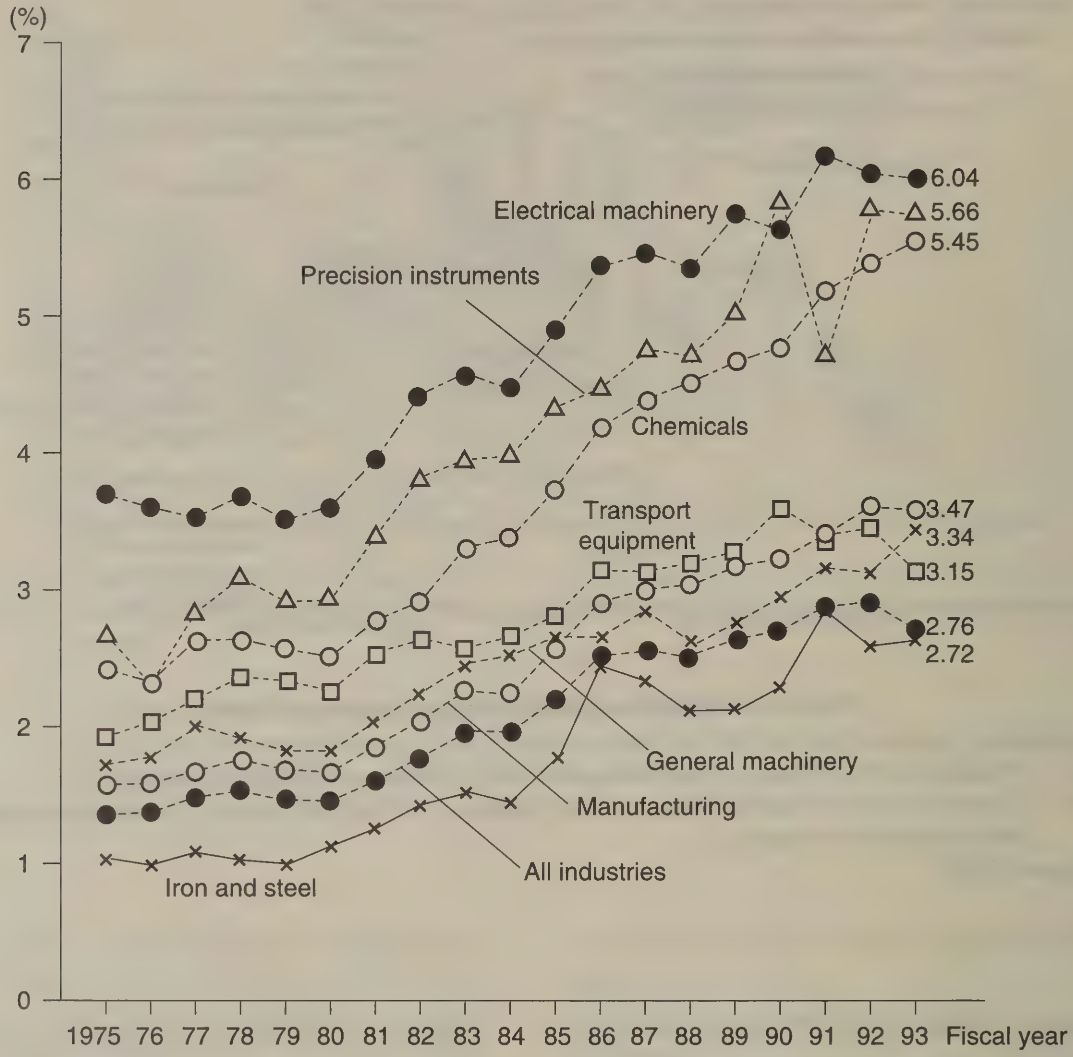

Figure 2-1-10 Ratio of R&D expenditures to sales figures in selected industries

Note: Figures are for private companies only. Public corporations are not included.
Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 10)

it is necessary to take into consideration the fact that this is affected by fluctuations in sales due to changes in economic conditions, the ratio for all industry reached 2.76% in FY1993. It was lower than the previous year. Principal industries with a high R&D to sales ratio are electrical machinery (6.04%), precision instruments (5.66%) and chemicals (5.45%) (Figure 2-1-10).

2.1.2.2.2 Research Institutions

Research institutions in Japan may be classified as national, local government-owned, private including nonprofit organizations such as foundations, and research-centered public corporations. National and local government-owned research institutions and public corpora-

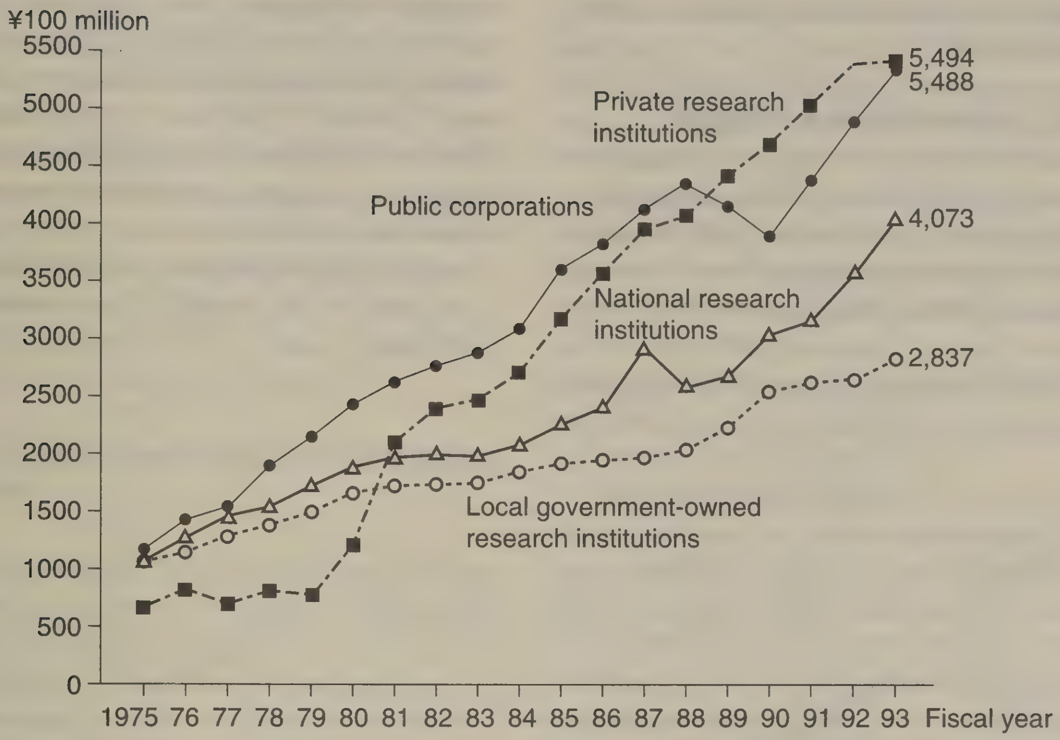

Figure 2-1-11 Trends in R&D expenditures by research institution

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 5)

tions are conducting research necessary to implement policies in the following fields.

- Basic and leading research
- Large-scale research such as nuclear energy development and space development
- Research to secure resources such as food and energy
- Research to support small-to-medium-sized enterprises
- Research to promote significant local industries for the development of the local economy
- Research that is beyond the capabilities of the private sector

The R&D expenditures by research institutions in Japan for FY1993 were 1,789.2 billion yen (The average annual rate of increase in real terms between FY1988 and FY1993 was 5.4%). This was 14.3% of the nation's total R&D expenditures. The government provides most of the R&D funds for national and local government-owned research institutions and public corporations and 31.4% of the R&D funds to private sector research institutions. As a result, the government provides 77.2% of the total funds for research institutions.

R&D expenditures by organizations in FY1993 were as follows (Figure 2-1-11);

- National research institutions: 407.3 billion yen (22.8% of total for research institutions)
- Local government-owned research institutions: 283.7 billion yen (15.9%)
- Private research institutions: 549.4 billion yen (30.7%)

- Research-centered public corporations: 548.8 billion yen (30.7%)

2.1.2.2.3 Universities and Colleges

The universities and colleges, as institutions of higher education, have an important role in cultivating research personnel while at the same time carrying out a broad area of research activities, especially basic research, to search for the truth.

The universities and colleges R&D expenditures in FY1993 were 1,685.5 billion yen, which was 13.5% of the total R&D expenditures for the nation (The average annual rate of increase from FY1988 to FY1993 was 5.5% in real terms). More than half of the R&D expenditures by universities and colleges are disbursed by national universities and colleges.

- National universities and colleges: 946.4 billion yen (56.1% of total for universities and colleges)

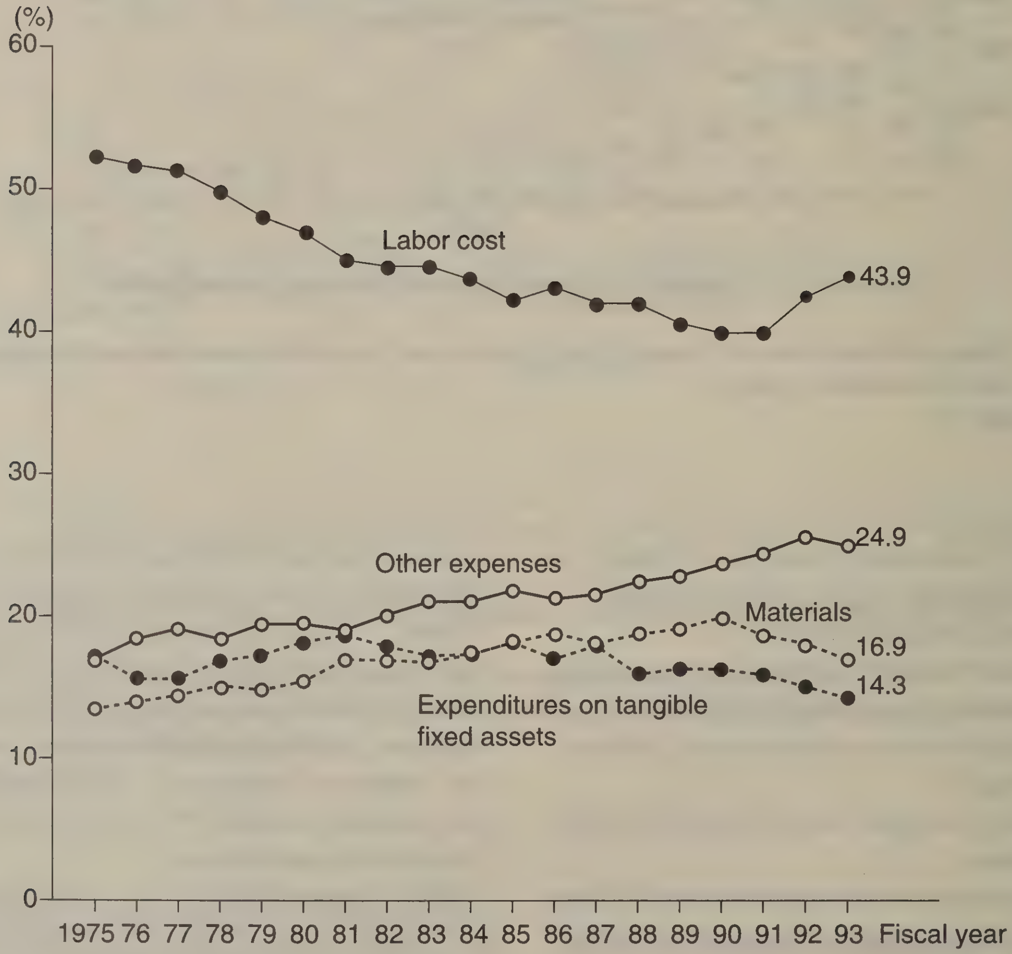

Figure 2-1-12 Trends in R&D expenditures by consisting elements

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 6)

- Public universities and colleges: 97.9 billion yen (5.8%)
- Private universities and colleges: 641.3 billion yen (38.0%)

Viewing the R&D expenditures by field (by university and college department), the health and engineering shares were relatively large.

- Physical sciences: 260.4 billion yen (15.4%)
- Engineering: 617.9 billion yen (36.7%)
- Agriculture sciences: 117.5 billion yen (7.0%)
- Health: 689.7 billion yen (40.9%)

2.1.2.3 R&D Expenditures by Consisting Elements

R&D expenditures consist of labor costs, materials, expenditures on tangible fixed assets (land and buildings, machinery, instruments, equipment and others) and other expenses.

The changes in the breakdown of Japan's R&D exppenditures by consisting elements show that labor costs are consistently the highest. The proportion of personnel expenses increased in the early 1970s, and started to decrease from FY 1975. However, it increased beginning in FY1992, and reached 43.9% in FY1993. A slight increase had been seen in the proportion of raw materials until 1990, but there was a consecutive three-year decrease starting in FY 1991. The proportion in FY 1993 was 16.9%. The ratio of expenditures on tangible fixed assets decreased to 14.3%. The share of other costs, including purchases of books used for research, utilities, travel, and communications, had been increasing during the past few years, and accounted for 24.9% in FY1993. It was lower than the previous year. (Figure 2-1-12).

Labor costs as a share of company R&D expenditures had showed a slight decrease through 1980s, but this proportion grew consecutively in FY1992 and FY1993, reaching 43.8% in FY1993.

A look at research institutions by organization shows that the ratio of labor costs in local government-owned research institutions is high. On the other hand, public corporations have higher ratio of expenditures for the purchase of tangible fixed assets because they include those requiring large-scale facilities and equipment for nuclear and space R&D.

Universities and colleges have higher ratios of labor costs than companies and research institutions. In FY1993, university and college ratios of labor costs were 58.8%. This was 72.3% for public universities and colleges. By field, physical sciences and engineering have higher ratios of expenditures on tangible fixed assets than the average ratio in universities and colleges (Figure 2-1-13).

2.1.3 R&D Expenditures by Character of Work

Classification into basic research, applied research and development[6], may differ from country to country. Although it is difficult to make a comparison due to differences in distinctions between the three among the countries concerned, R&D expenditure data by character of work generally reflects the R&D activity of each country. Recent statistical data for Japan, the United States, Germany and France shows that Germany and France spends more on basic research. The composition of R&D is similar in Japan and the United States (Figure 2-1-14).

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[6] Report on the Survey of Research and Development compiled by the Statistics Bureau, Management and Coordination Agency defines classification of research by character of work as follows.

- Basic research: research undertaken primarily for the advancement of scientific knowledge, where a specific practical application is indirectly sought.
- Applied research: research undertaken primarily for the advancement of scientific knowledge, with a specific practical application sought directly.
- Development: the use of available knowledge obtained as the result of basic and applied research and/or practical experience which is directed to the introduction of new materials, equipment, products, systems and processes, etc., or the improvement of such already made available.

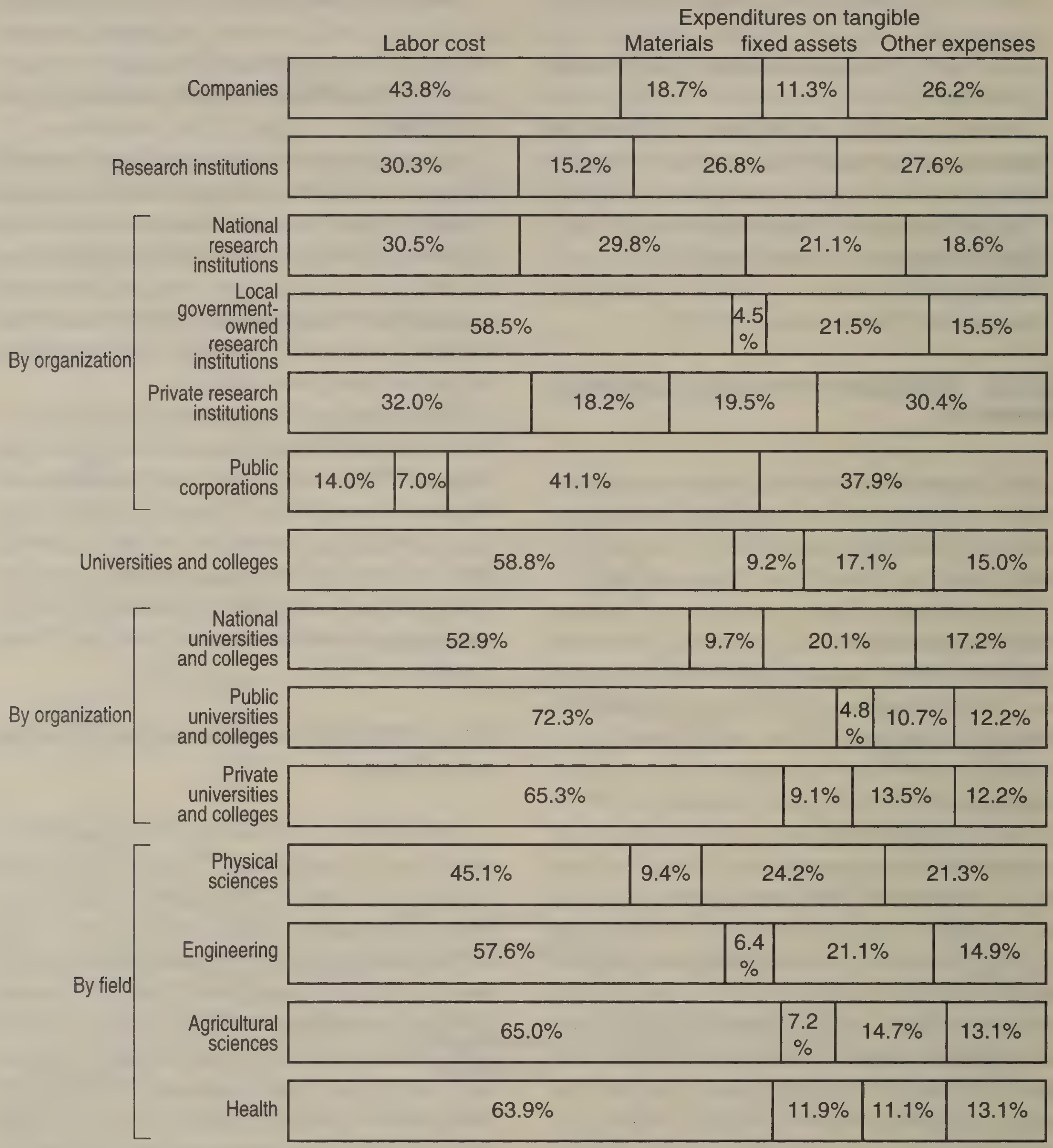

Figure 2-1-13 R&D expenditures by sector and by consisting elements (FY 1993)

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 6)

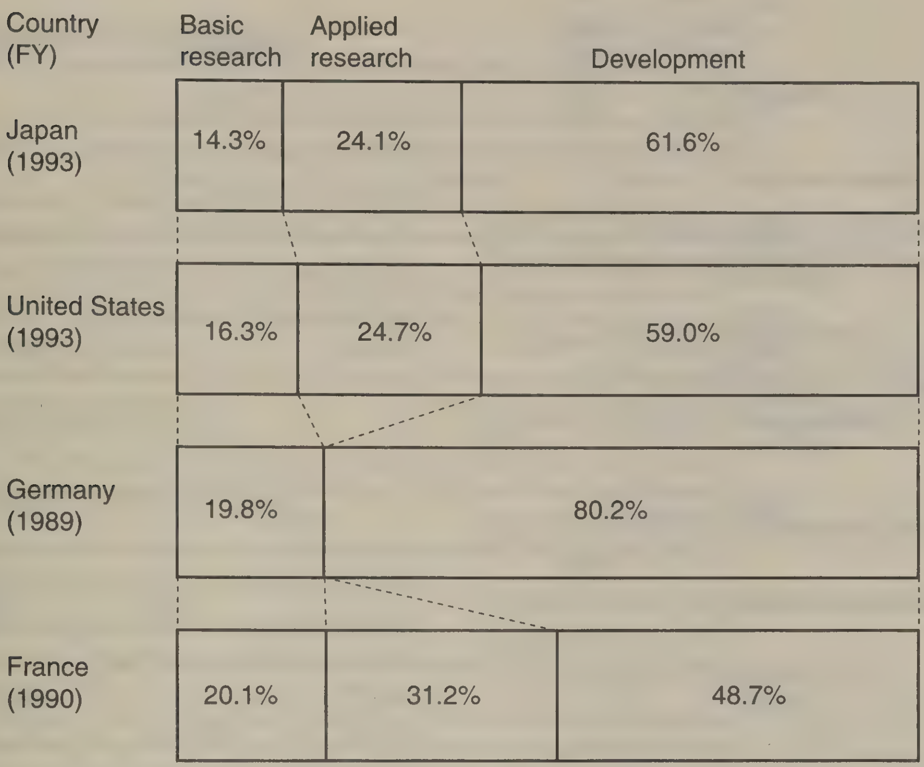

Figure 2-1-14 R&D expenditures by character of work in selected countries

Notes: 1. The figure for the United States is an estimate.
2. There is no distinction in Germany between applied research and development.
Sources: Japan, the U.S. — Same as in Figure 2-1-1.
Germany and France — OECD statistics.
(See Appendix 3)

Japan's R&D expenditures by character of work among companies, research institutions, and universities and colleges are distinctly different. Companies spend more on development due to the nature of corporate activities. Universities and colleges give priorities to basic and applied research. Research institutions fall between the two categories (Figures 2-1-15).

The composition ratio of R&D expenditures by character of work for companies are 6.7% for basic research, 21.4% for applied research and 71.9% for development of total expenditures in FY1993.

A look at research institutions by organization shows that national research institutions conduct more basic research and local government-owned research institutions conduct more applied research. Public corporations conduct an especially large amount of development.

Looking at universities and colleges by field, more basic research is conducted in the physical sciences and more applied research is conducted in the health fields.

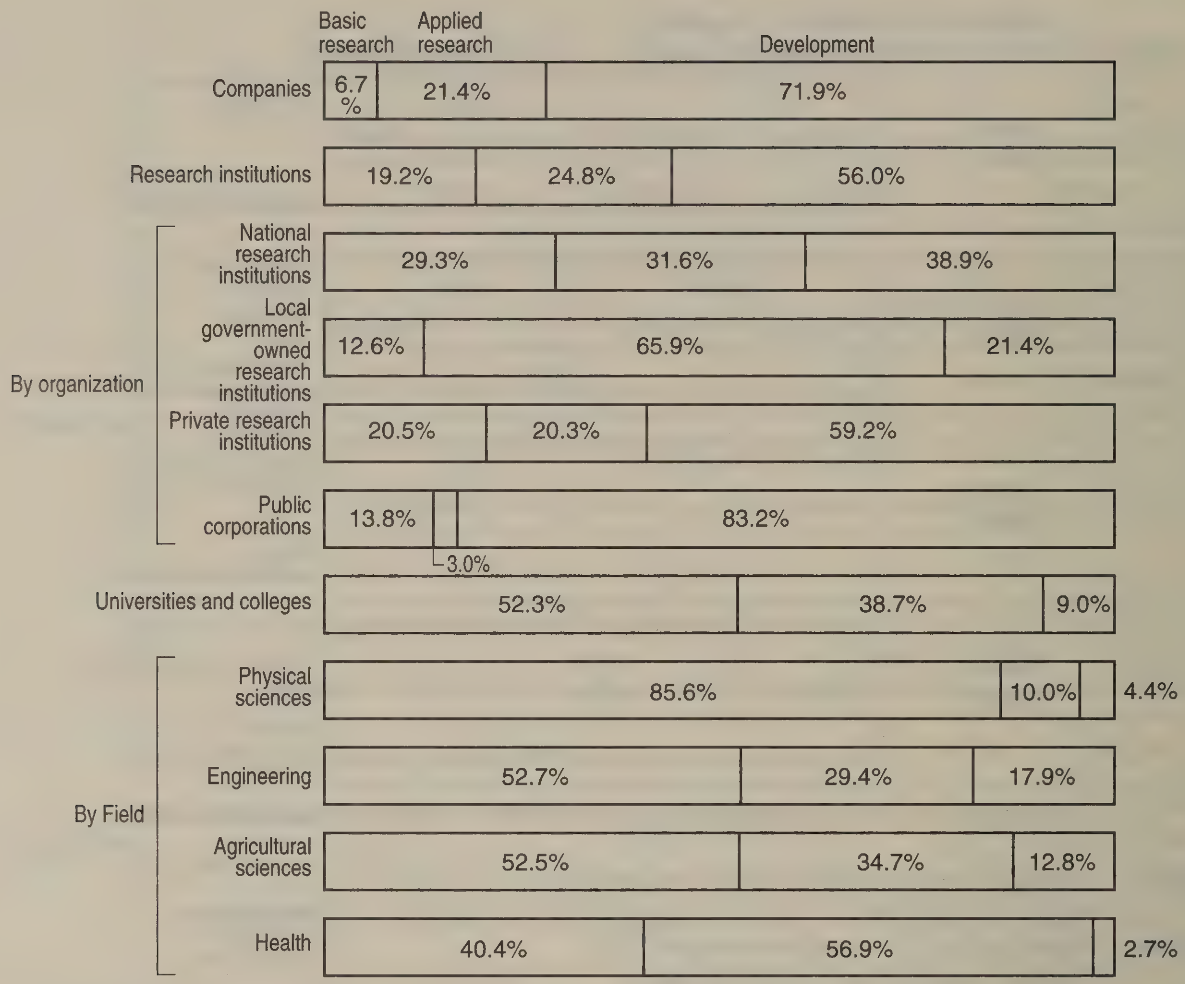

Figure 2-1-15 Composition of R&D expenditures by character of work by sector (FY 1993)

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 3)

2.2 Research Personnel

Statistics on research personnel, along with those on R&D expenditures, is another effective indicator of the extent of research activities. Personnel engaged in R&D7) can be classified as researchers and support personnel (assistant research workers, technicians, and clerical and other supporting personnel).

2.2.1 Researchers

2.2.1.1 Number of Researchers

Countries use different methods for determining the number of researchers. As a result, simple comparisons may not be precise. It is useful, however, to look at general trends for each country from its own statistics. The United States had the most followed by Japan and Germany in the order named (Figure 2-2-1).

Looking at the changes in the number of researchers in Japan, in 1994 the number of researchers was 558,000 (641,000 including social sciences and humanities). It was 541,000 in the previous year (622,000 including social sciences and humanities). This was a 3.2% increase (3.0% including social sciences and humanities) over the previous year.

The average annual rates of increase are as follows:

- 1965 – 1970: 7.9%
- 1970 – 1975: 8.2%
- 1975 – 1980: 3.5%
- 1980 – 1985: 4.7%
- 1985 – 1990: 4.9%
- 1990 – 1994: 3.6%

2.2.1.2 Number of Researchers per 10,000 Population and per 10,000 Labor Force

Japan has the highest number of researchers per 10,000 population and per 10,000 labor force, exceeding even the United States (Figure 2-2-2).

2.2.1.3 Number of Researchers by Sector

The number of researchers by sector in Japan is as follows:

- Industry: 367,000 (65.8%)
- Universities and colleges: 151,000 (27.1%)
- Government research institutions (including public corporations): 28,000 (5.0%)

The United States has a greater percentage of researchers working in industry, and the percentage of researchers in its government research institutions is low, similar to Japan. The ratio of researchers at universities and colleges in the United States is also low. The ratio of government researchers in Germany is higher than that of Japan and the U.S. The ratio of researchers in industry in France is low, as researchers are concentrated in government, research institutions, universities and colleges. In the United Kingdom, the ratio of researchers in industry is

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7) "Report on the Survey of Research and Development" compiled by the Statistics Bureau, Management and Coordination agency classifies personnel engaged in R&D as follows.
Researcher: Persons who hold a university degree (or persons who have equivalent or greater knowledge in their specialty), who have research experience of at least two years, and who are engaged in research activities in their own chosen subject. "Researchers" as used herein, refers only to full-time researchers, and excludes those who also perform other duties in addition to research. (However, the term "research expenses" does refer to expenses related to the latter.)
Assistant research workers: persons who assist researchers and who are engaged in research activities under their direction and who have the possibility of becoming researchers in the future.
Technicians: Persons, other than researchers and assistant research workers, who are engaged in technical services related to research activities under the guidance and supervision of' researchers and assistant research workers.
Clerical and other supporting personnel: Excepting those mentioned above, persons who are engaged in miscellaneous activities, clerical work, accounting, etc. relating to research activities.
Japanese statistics on persons engaged in R&D are as of April 1 of the appropriate year.

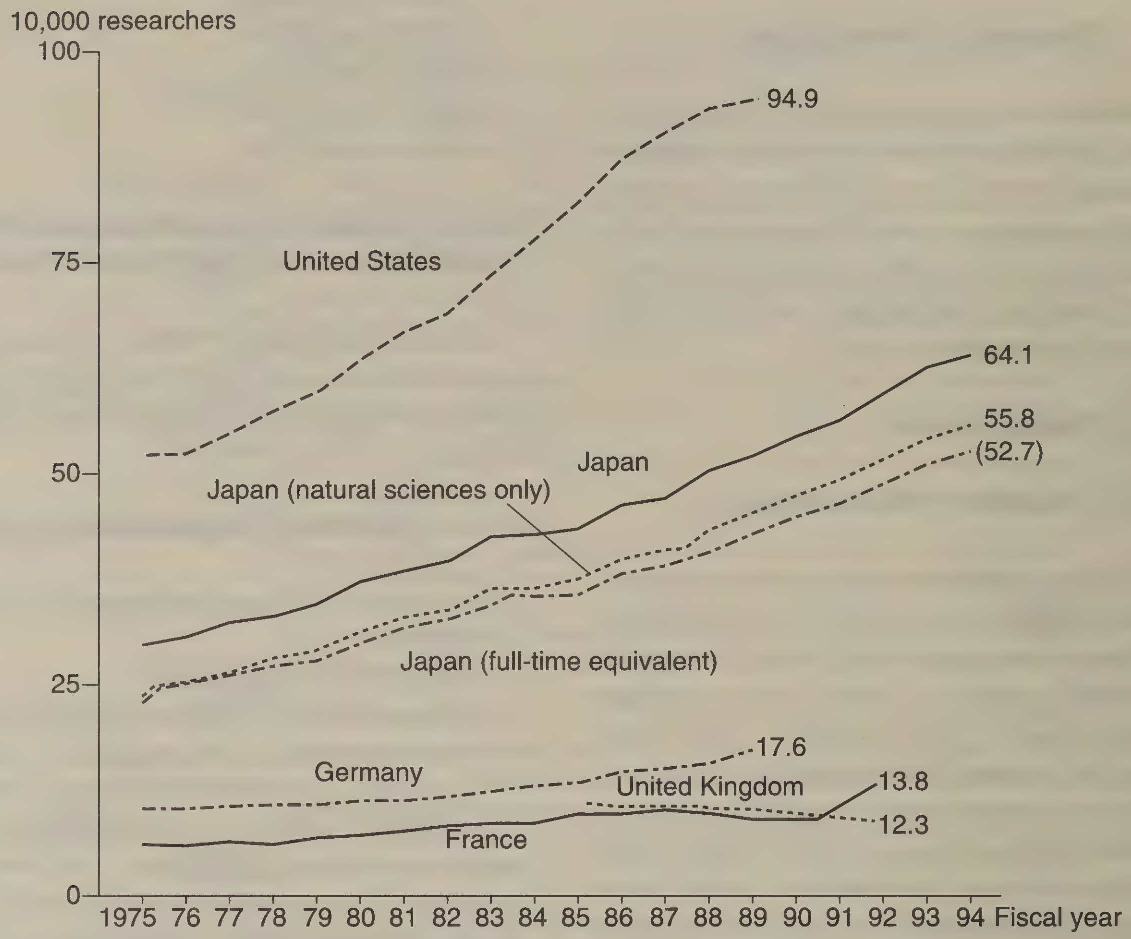


Figure 2-2-1 Trends in number of researchers in selected countries

Notes: 1. The figures for all countries include social sciences and humanities. The statistics for Japan also show numbers for researchers in natural sciences only.

2. Only the figures for Japan are not on a full-time equivalent basis.

3. Germany and France: The years for which data are not available are indicated as a straight line.

Sources: Same as in Figure 2-1-1.

France — OECD statistics for the data before 1981.

(See Appendix 1)

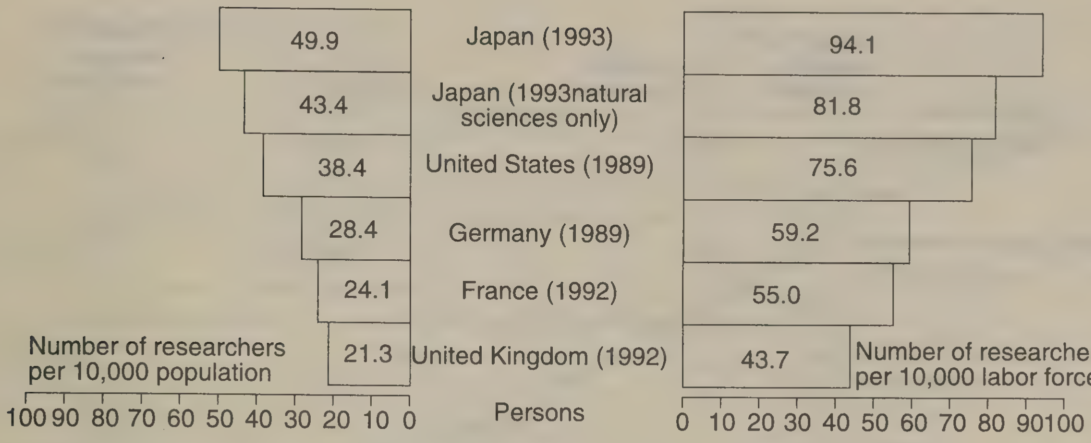


Figure 2-2-2 Researchers per 10,000 population and 10,000 labor force

Notes: 1. The figures for all countries include social sciences and humanities. The statistics for Japan also show the data for researchers in natural sciences only.
2. Only the figures for Japan are not on a full-time equivalent basis.
Sources: Numbers of researchers data: Same as in Figure 2-1-1.
Population and labor force data: Japan — "Population Estimates Series" and "Monthly Report on the Labor Force Survey" by the Statistics Bureau, Management and Coordination Agency.
U.S. — Data from the Department of Commerce and the Department of Labor.
Other countries — OECD statistics.
(See Appendix 1)

high and the ratio of researchers in universities and colleges is low (Figure 2-2-3).

The following sections show the characteristics of researchers in Japan by sector.

2.2.1.3.1 Companies

In the last 10 years from 1984 to 1994, the number of researchers in companies has increased 1.64 times (an average annual rate of increase of 5.1%) (Figure 2-2-4).

In industry, 351,000 of the researchers are in manufacturing (95.6%). Of all researchers within manufacturing, the electrical machinery industry tops the list at 141,000 researchers or 38.3% of the total. Next is the chemical industry with 59,000 researchers or 16.1%. These two industries account for approximately half of all company researchers.

By field of research, engineering ranks the highest at 61.3%. Next is the physical sciences at 25.2%, followed by health at 3.6%, and finally agricultural sciences at 2.6%. Within the engineering field, researchers are concentrated in electrical and telecommunications engineering, mechanical engineering, shipbuilding and aeronautical engineering. Within the physical sciences, chemistry has the majority. These three fields employ three-fourths of all company researchers (Figure 2-2-5).

Regarding the number of researchers per 10,000 employees, the average number throughout all industry sectors is 542. The average number in the manufacturing sector is highest at 654. Within manufacturing, following sectors rank at the top (Figure 2-2-6).

- Electrical machinery: 1,103
- Chemical products: 987
- Precision instruments: 933

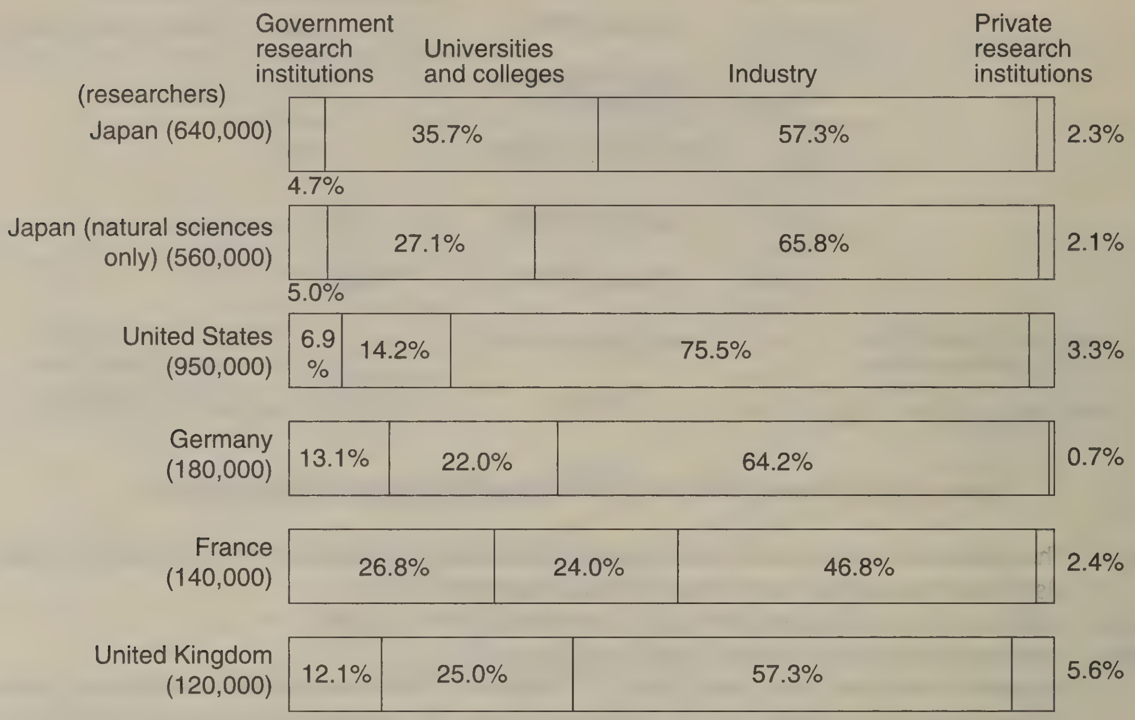


Figure 2-2-3 Share of researchers by sector in selected countries

Note: Japan: 1994, United States: 1989, Germany: 1989, France: 1992, United Kingdom: 1990.
Source: Same as in Figure 2-1-1. However, the source for United States is the National Science Foundation's "National Patterns of R&D Resources".

2.2.1.3.2 Research Institutions

For the last 10 years, researchers in research institutions have increased by 1.24 times (an average, annual rate of increase of 2.2%). This is due to an increase in the number of private research institutions. Looking at the number of researchers by organization, the national research institutions have 10,000 researchers or 26.5% of the total for research institutions, local government-owned research institutions have 14,000 researchers at 34.5%, private research institutions have 12,000 researchers at 30.0%, and public corporations have 4,000 researchers at 9.0% (Figure 2-2-7).

By field, researchers in engineering are most numerous at 40.4%, next is agricultural sciences at 31.6%, followed by the physical sciences at 20.4%, and finally health at 6.8% (Figure 2-2-8).

2.2.1.3.3 Universities and Colleges

The number of researchers at universities and colleges has increased by 1.33 times in the last 10 years (an average annual rate of increase of 2.9%). Looking at the number of researchers by type of institution in 1994, national universities and colleges have 85,000 researchers (56.1% of the total for universities and colleges), public universities and colleges have 10,000 researchers (6.9%), and private universities and colleges have 56,000 researchers (36.9%) (Figure 2-2-9).

By field, health ranks first at 56.1%, followed by engineering at 21.8%, physical sciences at 11.9%, and agricultural sciences at 6.3%.

According to the "Report on the Survey of Research and Development" by Statistics Bureau,

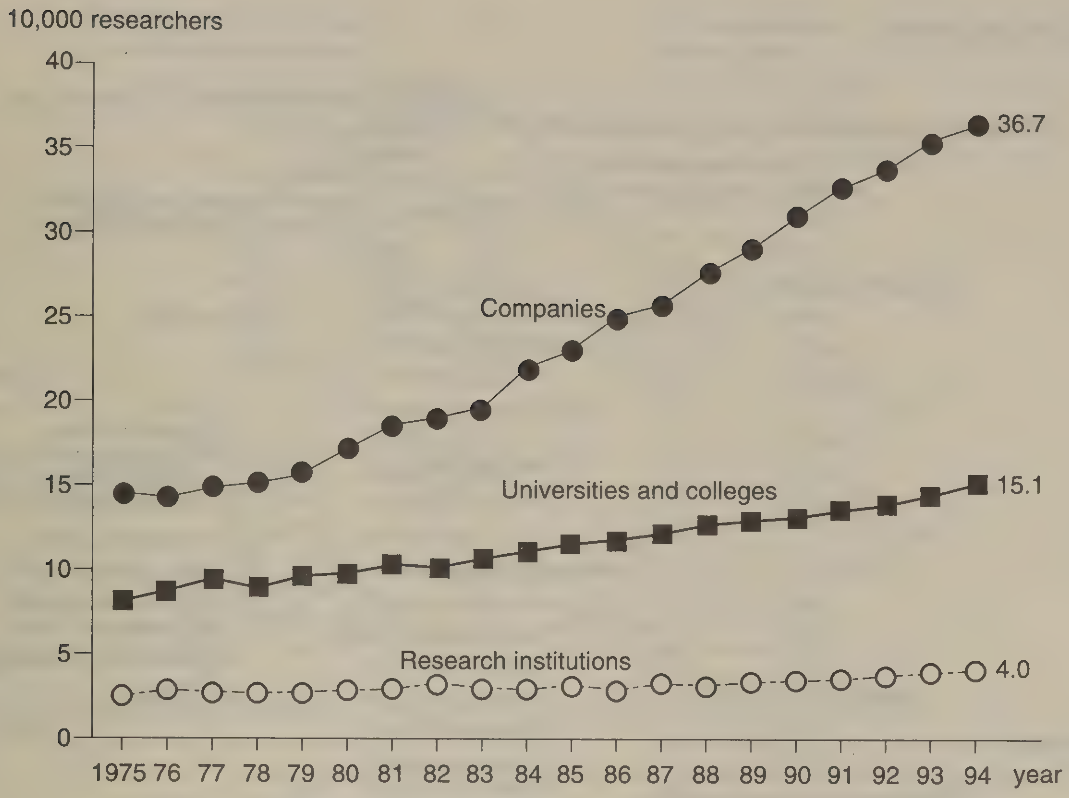
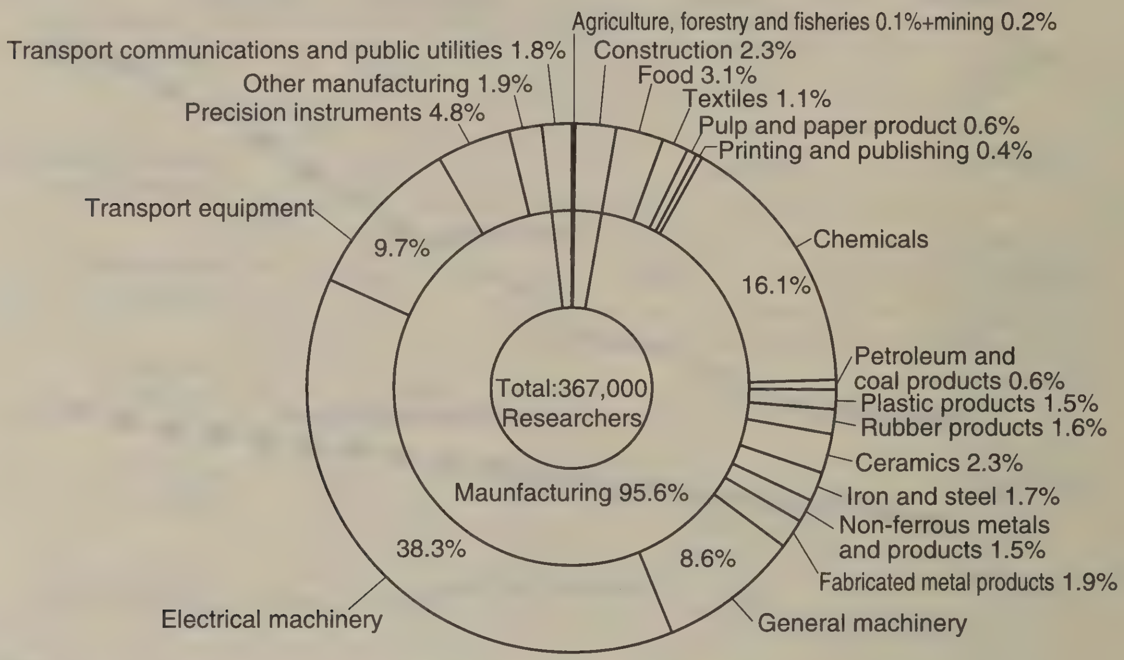


Figure 2-2-4 Trends in number of researchers by sector in Japan

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 8)

Management and Coordination Agency, Researchers in universities and colleges are classified into teachers, students for Ph.D. degree, medical staff and others. Looking at the composition of researchers by type of institution, in national universities and colleges, students for Ph.D. degrees make up a large ratio of the researchers, public universities and colleges have a greater ratio of medical staff and others, and private universities and colleges have a greater ratio of teachers and a smaller ratio of students for Ph.D. degrees (Figure 2-2-10).

(1) By industry sector



(2) By field

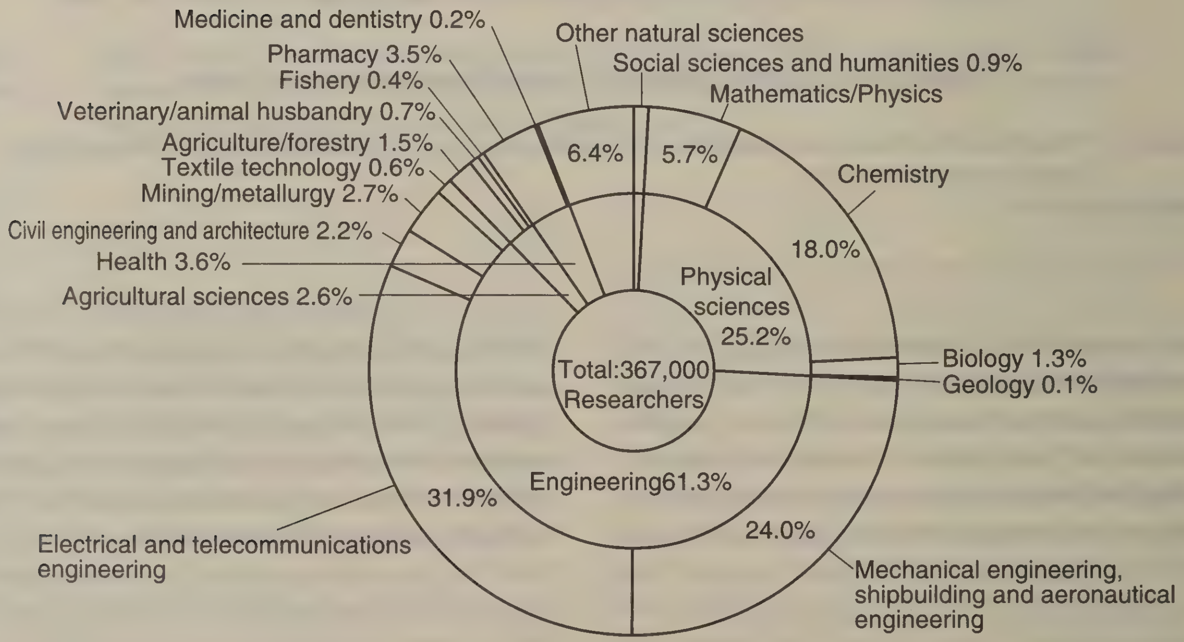


Figure 2-2-5 Number of company researchers by industry sector and by field of research (1994)

Note: Figures are their shares in percentages to total company researchers.
Souse: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 9)

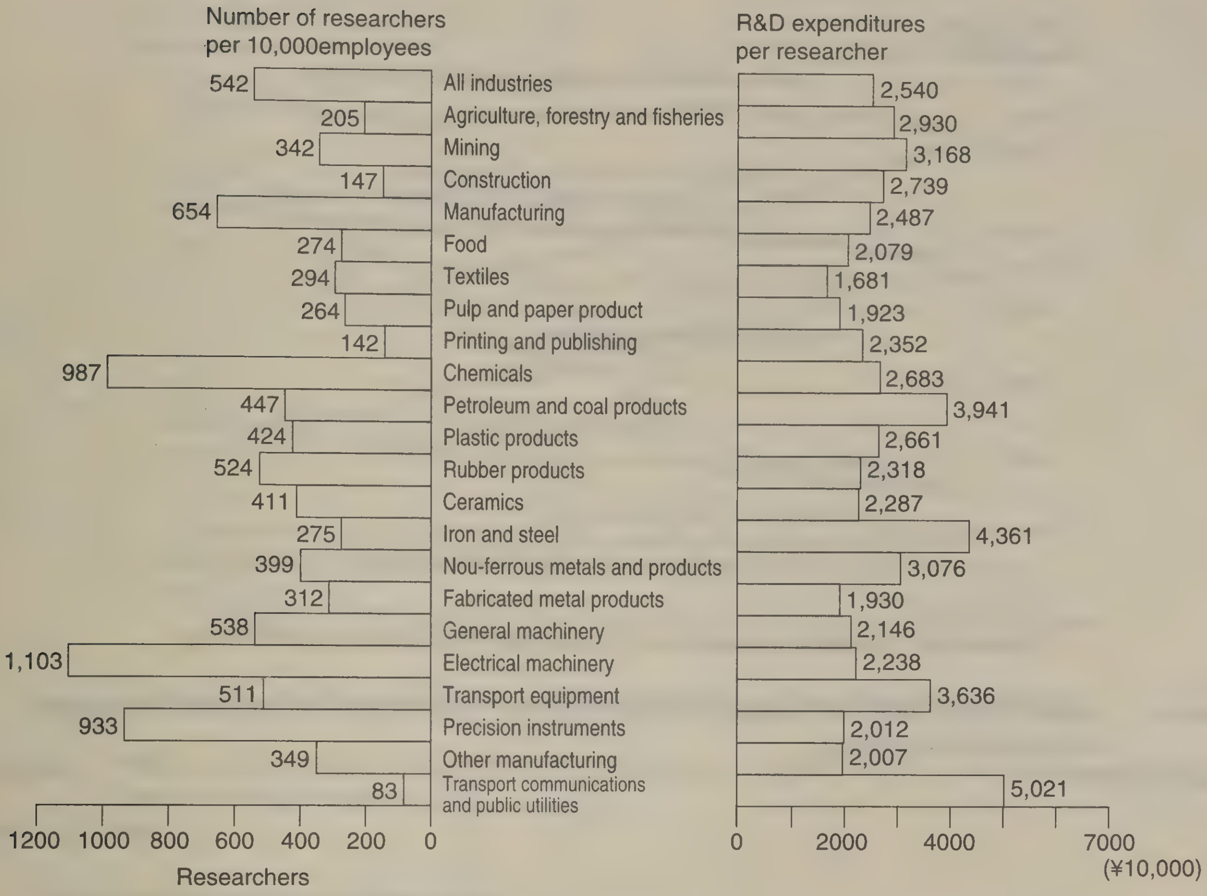


Figure 2-2-6 Number of researchers per 10,000 employees and R&D expenditures per researcher in companies

Notes: 1. Regarding researchers per 10,000 employees, the data for number of employees and number of researchers are as of April 1, 1994.

2. As for the R&D expenditures per researcher, the data for the number of researchers are as of April 1, 1993, and the data for research expenditures are as of FY1993.

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

(See Appendix 9)

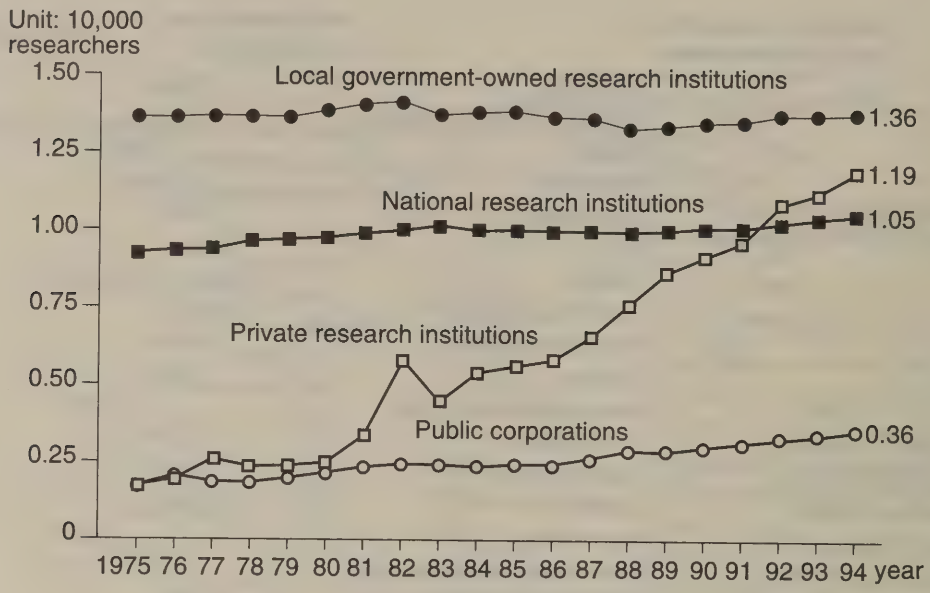


Figure 2-2-7 Trends in number of researchers in research institutions

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 8)

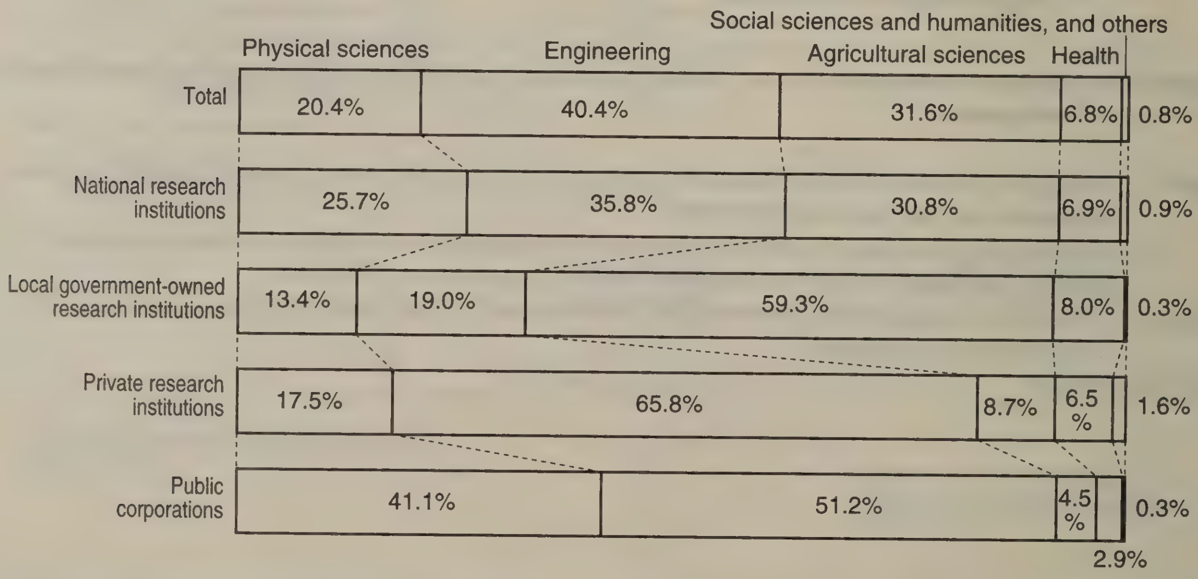


Figure 2-2-8 Share of researchers in research institutions by organization and field (1994)

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 8)

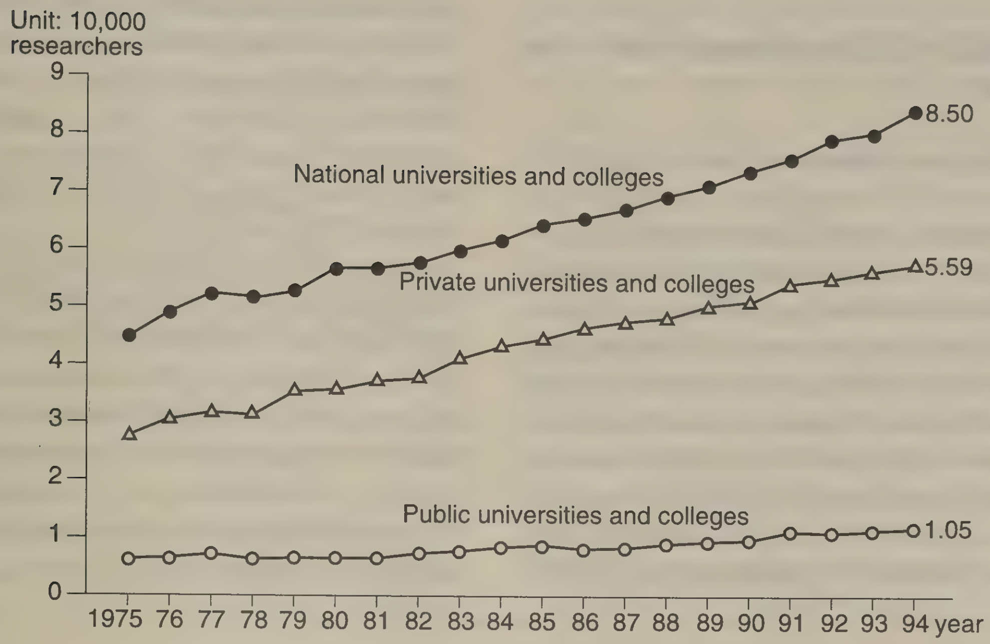


Figure 2-2-9 Trends in number of researchers in universities and colleges

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 8)

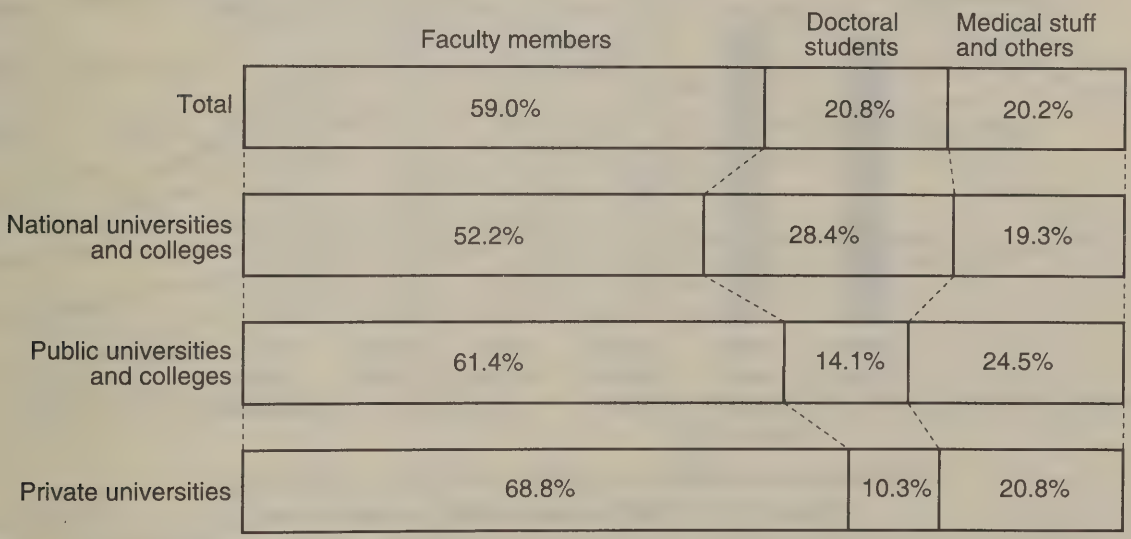


Figure 2-2-10 Composition of researchers in universities and colleges (1994)

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

2.2.2 R&D Expenditures per Researcher

Countries use different methods for determining the number of researchers. As a result, simple comparisons of R&D expenditures per researcher may not be precise. However, using statistics in major countries, R&D expenditures per researcher in Japan were 22.03 million yen (FY1993, 23.15 million yen: natural sciences only). R&D expenditures per researcher in other countries, using the IMF exchange rate for conversion to yen, were USA 20.46 million yen (FY1989); Germany 26.58 million yen (FY1989); France 29.15 million yen (FY1992); and United Kingdom 22.98 million yen (FY1992). Using OECD's purchasing power parity, the figures were USA 29.51 million yen (FY1989); Germany 34.16 million yen (FY1989); France 35.46 million yen (FY1992); and United Kingdom 31.09 million yen (FY1992) (Figure 2-2-11).

In Japan, R&D expenditures per researcher tended to increase through 1980s. However they decreased in FY1992 and 1993 accounting for 23.32 million yen (The standard is FY1990) (Figure 2-2-12). In FY1993, research institutions have the greatest R&D expenditure per researcher (46.06 million yen). Companies spent 25.40 million yen, and universities and colleges spent 11.55 million yen.

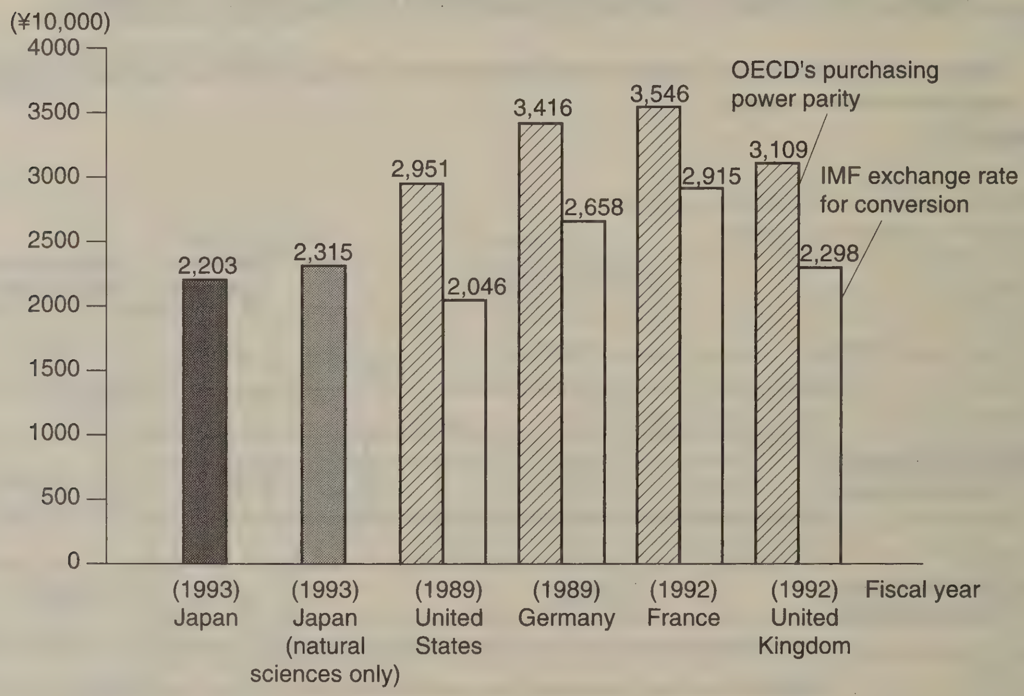


Figure 2-2-11 R&D expenditures per researcher

Notes: 1. For comparison, figures for all countries include social sciences and humanities. The figure for Japan shows also the amount with natural sciences only.
2. Only the figures for Japan are not on a full-time equivalent basis.
Source: Same as in Figure 2-1-1.
(See Appendix 1)

The following shows R&D expenditures per researcher in companies by industry sector.

- Transport / communications / public utilities: 50.21 million yen
- Mining: 31.68 million yen
- Construction: 27.39 million yen
- Manufacturing: 24.87 million yen

In manufacturing the following sectors have high R&D expenditures per researcher (Figure 2-2-6).

- Iron and steel: 43.61 million yen
- Petroleum and coal products: 39.41 million yen
- Transport equipment: 36.36 million yen

In research institutions, R&D expenditures per researcher by organization are as follows:

- Public corporations: 157.51 million yen
- Private research institutions: 48.92 million yen
- National research institutions: 39.22 million yen
- Local government-owned research institutions: 20.65 million yen

R&D expenditures per researcher in universities and colleges are on average 11.55 million yen. However, taking into consideration only teachers who are actually doing research, the figure is 19.33 million yen in all universities and colleges. This figure varies according to type of university and college as follows:

- National universities and colleges: 21.84 mil-

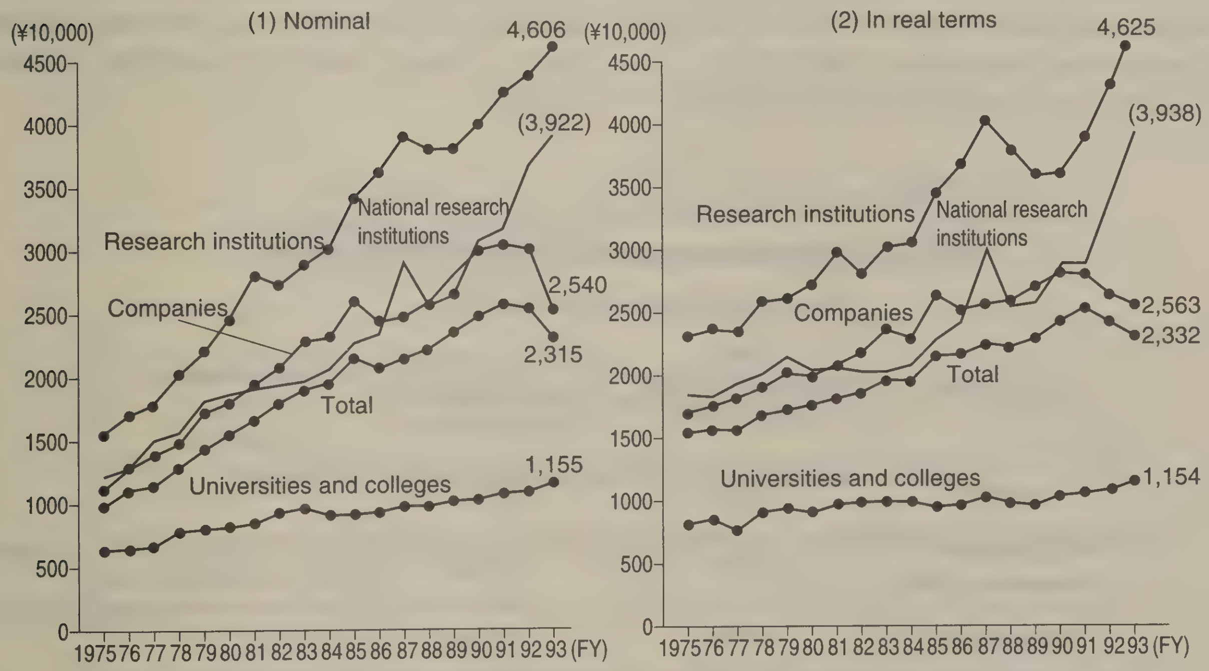


Figure 2-2-12 Trends in R&D expenditures per researcher

Notes: 1. Each figure equals R&D expenditures of the relevant fiscal year divided by the number of researchers (as of April 1).
2. Figures in real terms are converted in constant FY 1990.
3. The data for national research institutions are indicated in a thin line.

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

(See Appendix. 5, 8, 15)

lion yen

- Public universities and colleges: 15.84 million yen
- Private universities and colleges: 17.02 million yen

2.2.3 Personnel Engaged in R&D

Although the definition of personnel engaged in R&D is not same in each country, numbers of personnel engaged in R&D (including researchers) are as follows:

- Japan: 947,000 (847,000: natural sciences only)
- Germany: 426,000
- France: 308,000
- United Kingdom: 255,000

It is difficult to compare these numbers at face value. Compared with European countries, Japan has a comparatively low number of personnel supporting researchers (Table 2-2-13).

The number of personnel engaged in R&D in Japan has increased by 1.35 times (an average annual rate of increase: 3.0%) during the 10 years from 1984 to 1994. This increase was mostly due to the increase in numbers of researchers (Figure 2-2-14). The percentage of researchers of all personnel engaged in R&D has increased from 58.9% in 1984 to 65.9% in 1994. On the other hand, the share of assistant research workers decreased from 14.8% to 11.3%. The percentage of technicians decreased from 15.3% to 12.1%. Clerical and other supporting personnel have decreased from 11.0% to 10.6%. As a result, the number of assistant research workers and technicians per researcher has been decreasing and was 0.36% in 1994 (Figure 2-2-15).

A breakdown of the number of personnel engaged in R&D by sector shows that companies have a larger ratio of support personnel than other sectors and that universities and colleges have a larger ratio of researchers (Figure 2-2-16).

Table 2-2-13 Personnel engaged in R&D in selected countries

Country (year)	Total Number of personnel engaged in R&D	Number which are non-researchers	Non-researcher per researcher
Japan (1994)	947,455	306,372	0.48
Japan, natural sciences only (1994)	846,829	288,522	0.52
Germany (1989)	426,446	250,044	1.42
France (1992)	308,163	170,076	1.23
United Kingdom (1992)	255,000	132,000	1.07

Notes: 1. For comparison, figures for all countries include social sciences and humanities. The figure for Japan shows also the number with natural sciences only.
2. Figures for U.K. are in units of thousands of people.
Source: Same as in Figure 2-1-1.

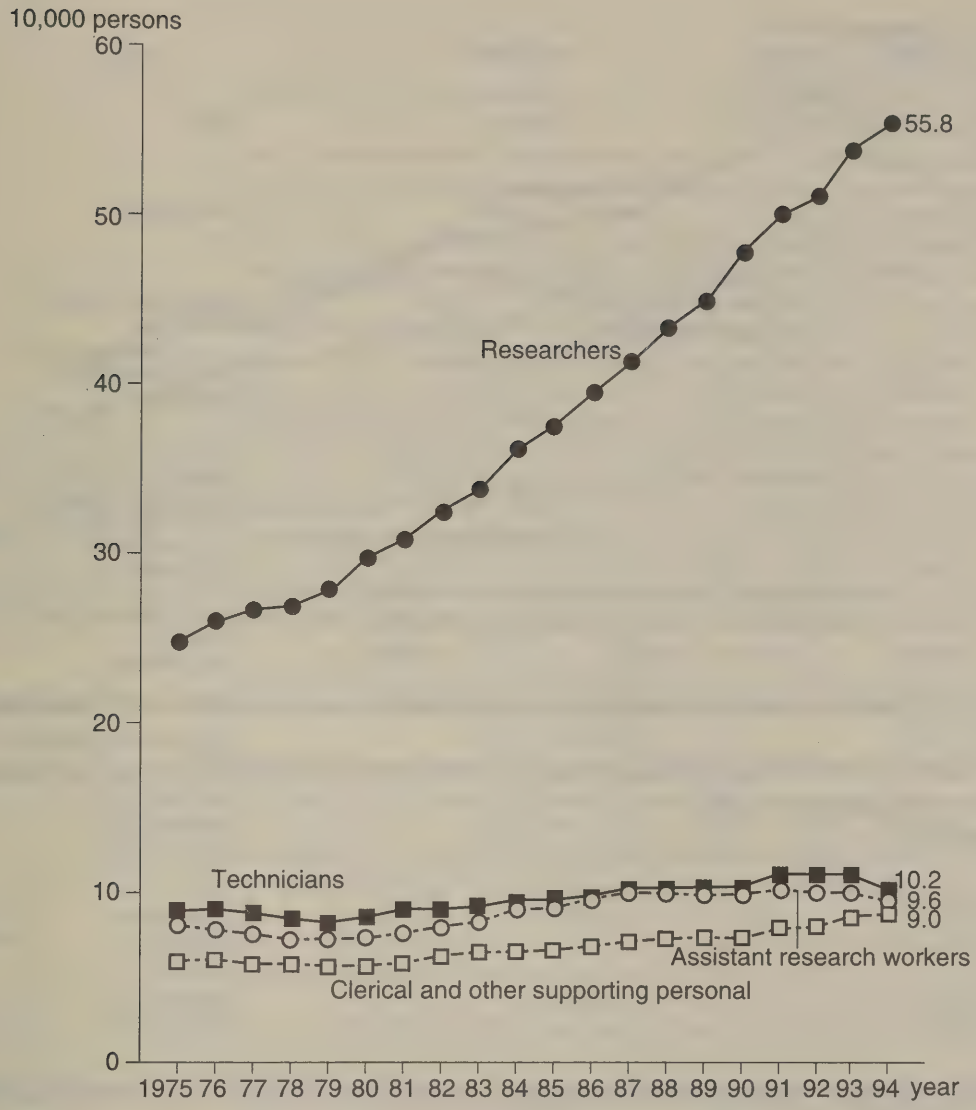


Figure 2-2-14 Trends in persons engaged in R&D in Japan

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 7)

In companies, the number of personnel engaged in R&D is 583,000. Researchers account for 367,000 (62.9% of the total for companies), assistant research workers 81,000 (13.9%), technicians 81,000 (13.9%), and clerical and other supporting personnel 54,000 (9.3%). Looking at the breakdown of personnel engaged in R&D by industry, the researcher ratio is high in transport/communications/public utilities (78.0%), construction (74.1%) and manufacturing (62.5%). In manufacturing, the researcher ratio is high in printing and publishing (80.5%) and precision instruments (68.7%) while the researcher ratio is relatively low in transport equipment (47.9%) and petroleum and coal products (51.7%).

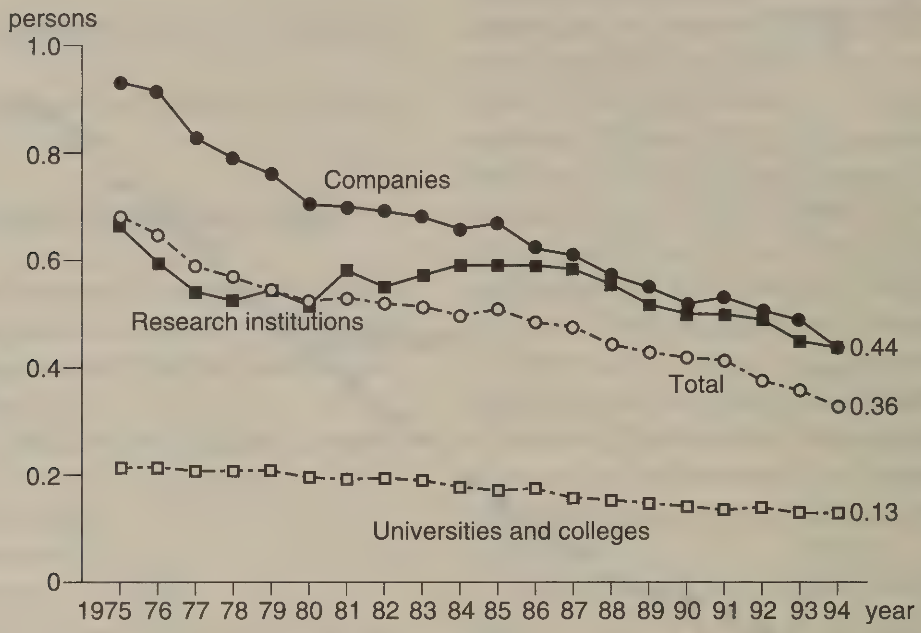


Figure 2-2-15 Trends in number of assistant research workers and technicians per researcher in Japan

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 7)

In research institutions the number of personnel engaged in R&D is 77,000. Researchers account for 40,000 (51.1% of the total for research institutions), assistant research workers 7,000 (9.4%), technicians 10,000 (13.3%), and clerical and other supporting personnel 20,000 (26.2%). The data by types of research institutions indicate that national and local government-owned research institutions have a larger ratio of researchers and private research institutions and public corporations have a larger ratio of assistant research workers.

Personnel engaged in R&D at universities and colleges total 186,000. Researchers account for 151,000 (81.5% of the total for universities and colleges), assistant research workers 8,000 (4.2%), technicians 11,000 (6.0%), and clerical and other supporting personnel 15,000 (8.3%).

2.2.4 Overall Degree Trends

An especially high percentage of students who have taken the master's or the doctor's degrees become researchers.

The number of degrees differ from country to country due to differences in culture and educational systems. Social factors such as industrial structure and number of students can affect the number of awarded degrees. Thus, it is difficult to compare the data at face value. It is useful, however, to compare trends, and this section describes the degree trends in natural sciences and engineering in selected countries.

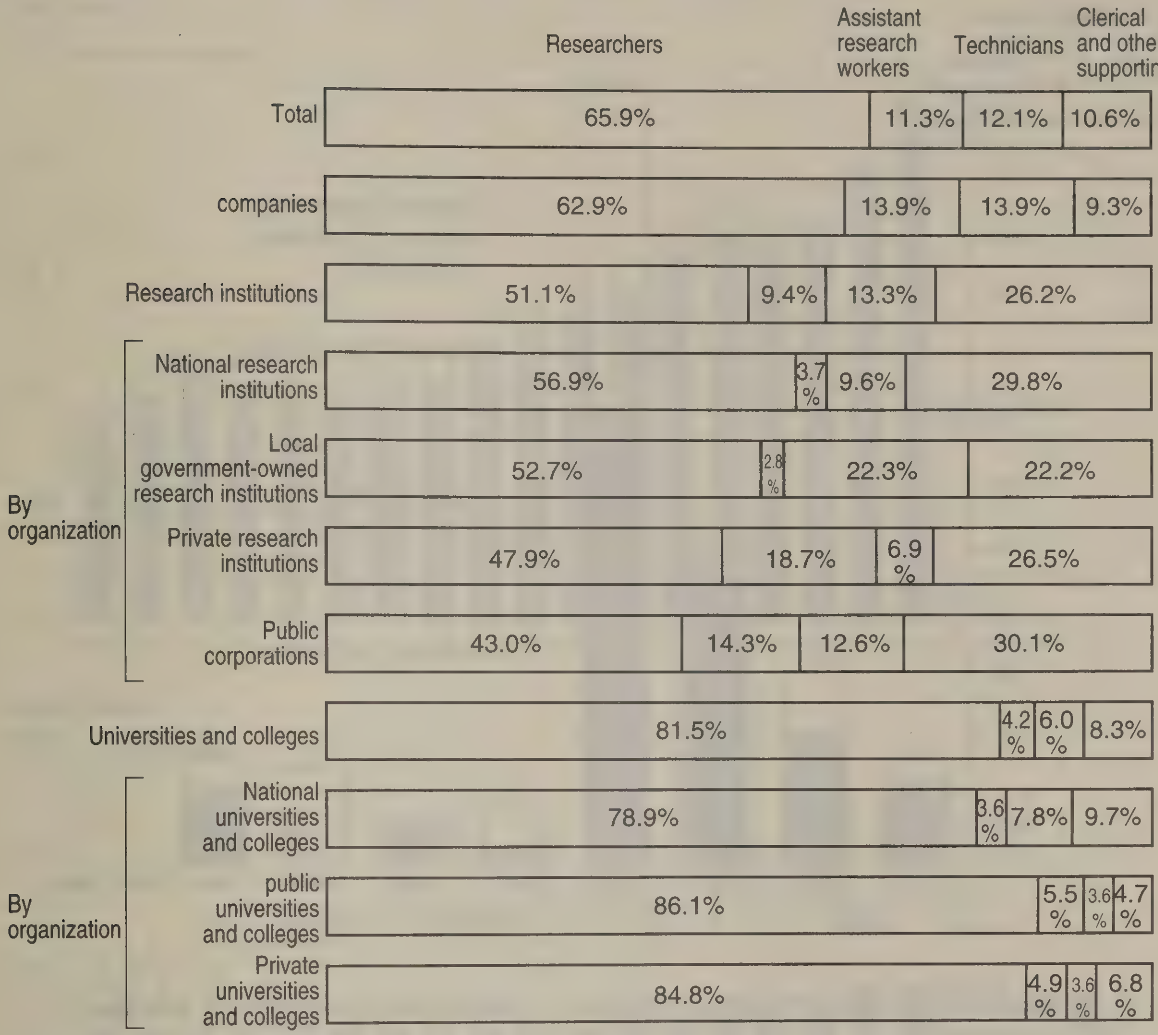


Figure 2-2-16 Composition of personnel engaged in R&D by sector in Japan (1994)

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

The United States awards the largest number of degrees, about 4 times as many as does Japan. Compared to ten years ago, the ratio of engineering degrees to total degrees has increased. Japan is second in number of degrees awarded following the U.S. and has a higher ratio in engineering. Germany, France, and the United Kingdom have about the same number. Germany and France have a higher ratio of degrees awarded in medical sciences, dentistry, pharmacy and health, the United Kingdom has a higher ratio in physical sciences (Figure 2-2-17).

In Japan the number of awarded degrees has increased in recent years. In FY1987, 17,160 master's degrees and 8,756 doctorates were awarded. In FY1992, 23,588 master's degrees (an increase of 37.5%) and 10,851 doctorates (an increase of 23.9%) were awarded. The largest increases have been in the ratios of master's degrees in physical sciences as well as engineering and doctorates in engineering (Figure 2-2-18).

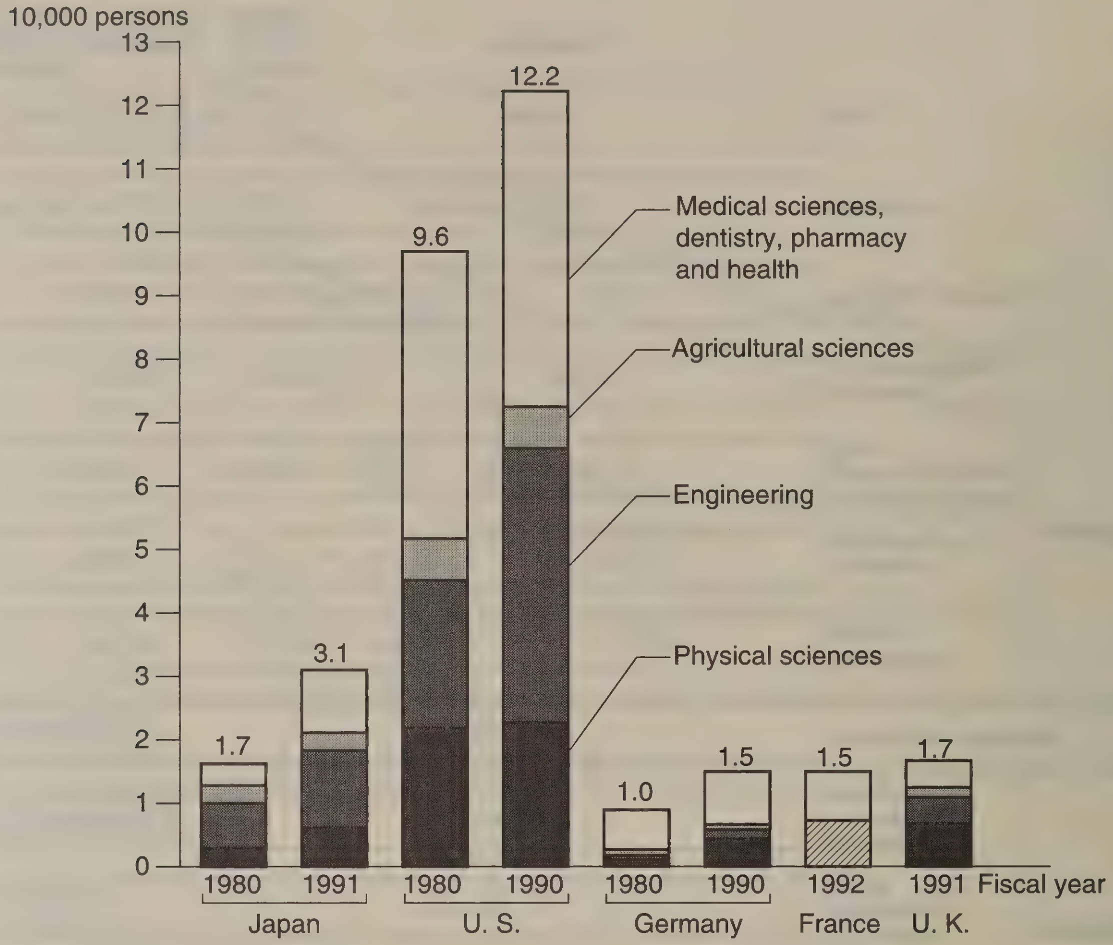


Figure 2-2-17 Number of awarded degrees in selected countries (Natural science)

Notes: 1. Totals include master's and doctoral degrees (Germany: only doctorates).
2. U.S. health degrees include first-professional degrees.
3. France does not distinguish between physical sciences, engineering, and agricultural sciences.
Source: "International Comparison of Education Indexes 1994" by the Ministry of Education.

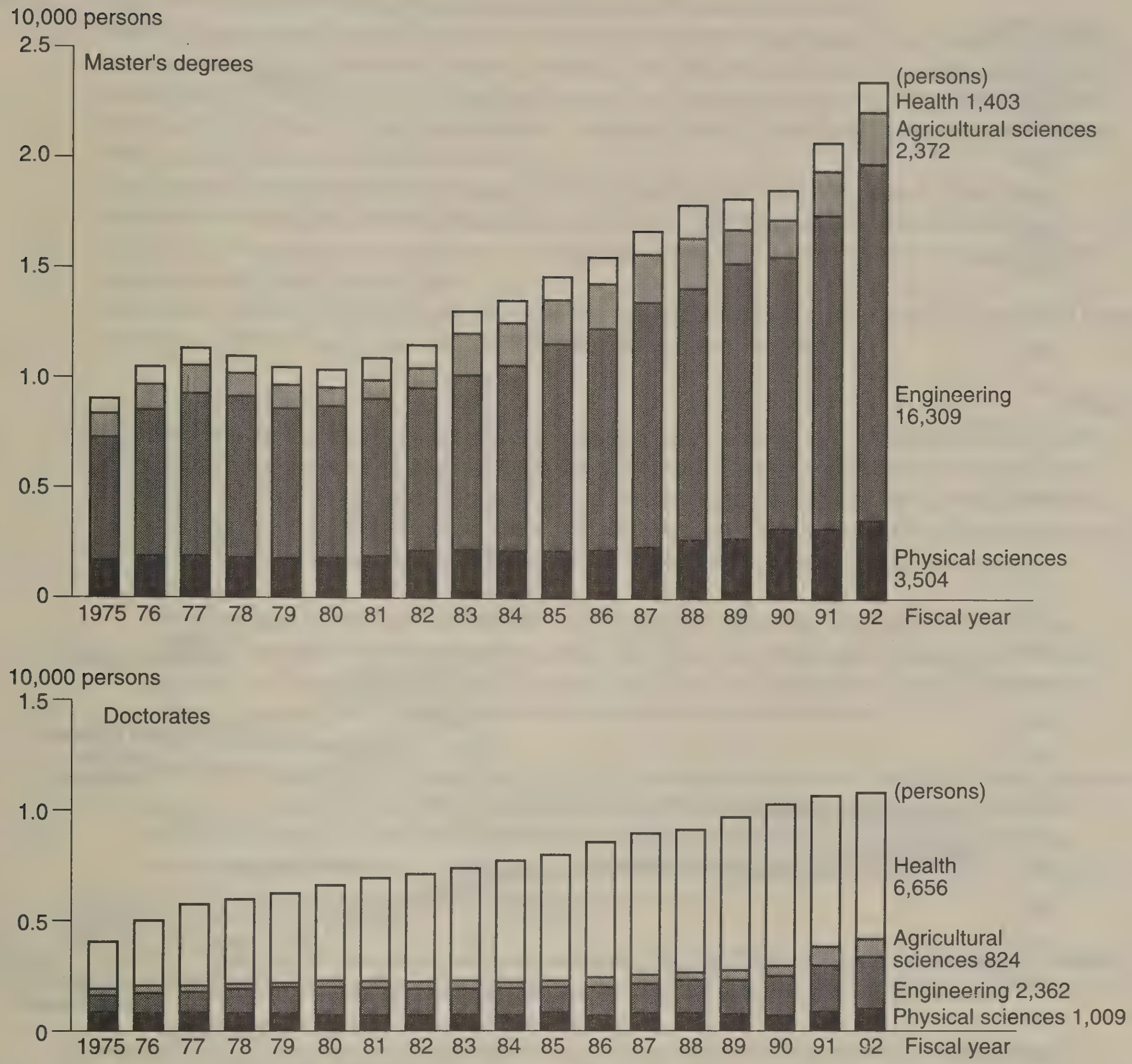


Figure 2-2-18 Degree Trends in Japan (Natural Science)

Note: The figures are awarded degrees in FY1992.
Source: "Statistical Abstract of Education, Science and Culture" by the Ministry of Education.

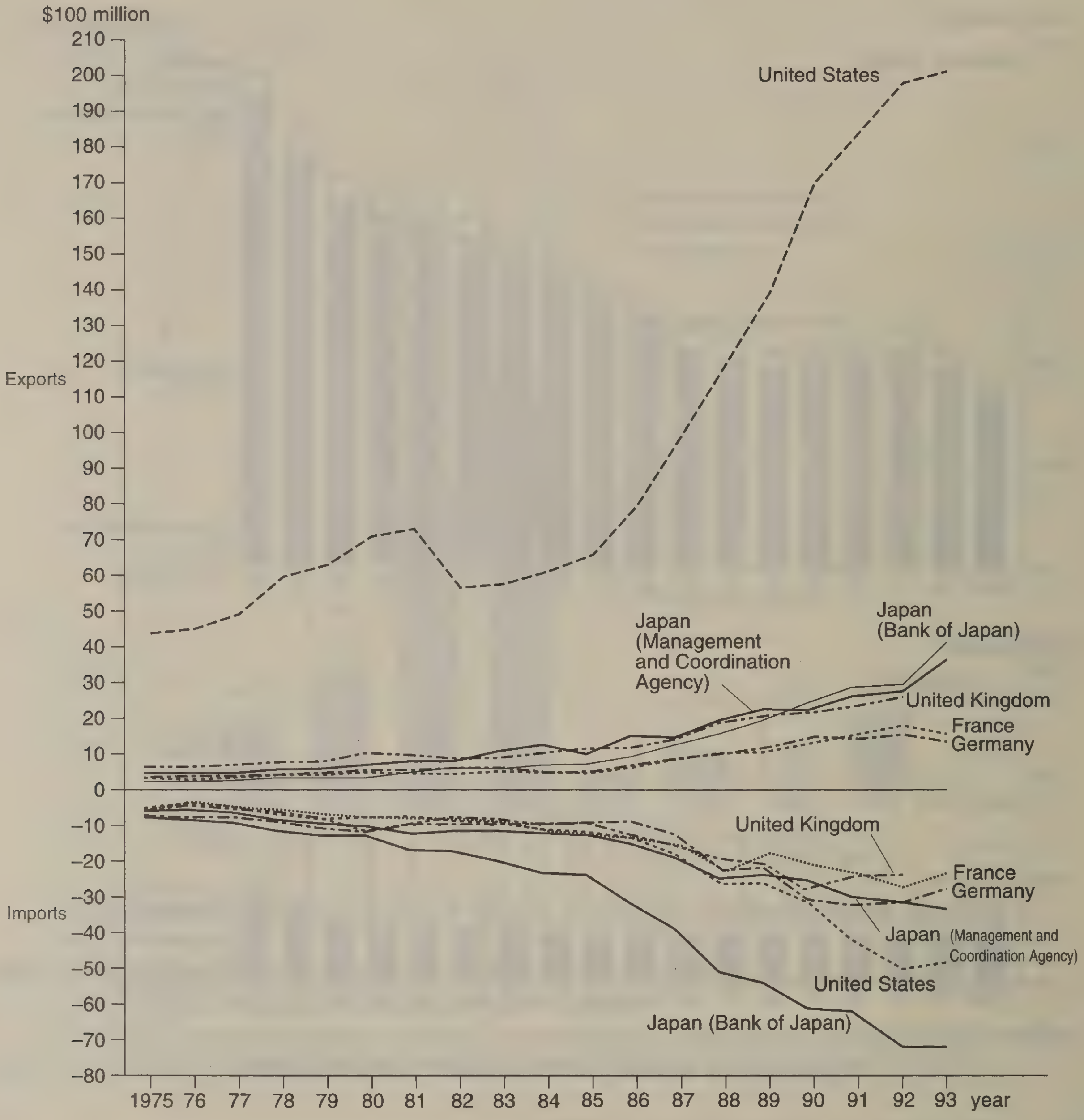


Figure 2-3-1 Trends in technology trade of selected countries

Notes: 1. The amounts are converted into dollars, based on IMF exchange rate.
2. Bank of Japan refers to the "Balance of Payments Monthly", compiled by the Bank of Japan. Management and Coordination Agency refers to the "Report on the Survey of Research and Development", compiled by the Statistics Bureau, the Management and Coordination Agency.
3. The figures are totals for the calendar year; the fiscal year is used only for the figures of Japan Management and Coordination Agency.
4. The United States changed the classification of statistics in 1982. Besides in 1992, the definition of import / export was reassessed, and from 1982 onward, figures were revised.
5. The United Kingdom changed its method of gathering data in 1987. Thus, new data cannot be compared with those prior to 1986.
6. The major reasons for differences between the figures provided by the Bank of Japan and those provided by the Management and Coordination Agency are as follows.

1) Survey Method
The data for the Bank of Japan's statistics are totals of all of the amounts listed under the international balance of payments heading of "Patent Royalties" in the report submitted based on the foreign exchange and foreign trade management law, while the data for the Management and Coordination Agency's statistics are designated statistics which are totals of the received responses of surveys which were mailed to companies.
2) Coverage
The coverage of the data for the Bank of Japan's statistics are all residents who made foreign exchange remittances of ¥3 million or more in service trade, while the coverage of the data for the Management and Coordination Agency's statistics exclude wholesalers, retailers, restaurants, finance companies and insurance companies.
3) The Scope of Technology Trade
The data for the Bank of Japan's statistics includes trademark and design considerations in addition to patent rights; utility model rights, know-how rights, technical guidance and so on. Furthermore, in the data for the Bank of Japan's statistics, the cases in which the technology export portion of industrial plant export were remitted as part of the plant export amount are not totalled as technological trade.

Sources: Japan — "Balance of Payments Monthly" compiled by the Bank of Japan, and "Report on the Survey of Research and Development" compiled by the Statistics Bureau, Management and Coordination Agency.
United States — "Survey of Current Business" compiled by the Department of Commerce.
German — "Technologische Diensteistungen Mai 1994" by the Deutsche Bundesbank.
France — "Statistiques et Etudes Financières", "La Balance des Paiements de la France" Ministers de l'Economie, des Finances et du Budget.
United Kingdom — "Business Monitor, Overseas Transactions" (1970-1979), Department of Trade and Industry. Central Statistical Office data (1980～).

(See Appendix 11,12,13)

2.3 Trends Related to Research Performance

The data on technology trade balances, number of patents applied for and granted, high-tech product trade balances and number of scientific papers, which indicates results of R&D activities in science and technology, reflect the activity and a nation's level and strength of R&D activities. These statistics are considered to be significant indicators demonstrating levels of R&D and technological strength.

This chapter describes these trends in Japan and selected countries.

2.3.1 Trade in Technology

Patents, utility models, and technical know-how are results of R&D efforts in science and technology. In addition to being used by corporations for their own purposes, they are traded internationally, for example in the form of transfer of rights, approval of utilization, and others. These transactions are what are known as technology trade.

2.3.1.1 Trends in the Technology Trade of Selected Countries

Looking at the value of technology exports and imports of the major countries; the trends of recent years are reflected in terms of advances in the globalization of corporate activities and emphasis of the importance of intellectual property rights, and the basic theme is expansion. In 1993 trends of stagnation or slight decrease began to be observed. (Figure 2-3-1).

The technology exports (value received) of the United States are significantly larger, at 20.4 billion dollars (1993, 2.268 trillion yen), than the following countries;

- Japan: 3.9 billion dollars (1993, 431.1 billion yen) ("Balance of Payments Monthly" by the Bank of Japan, referred to as the "Bank of Japan statistics" below)
- Japan: 3.6 billion dollars (1993, 400.4 billion yen) ("Report on the Survey of Research and Development" by Management and Coordination Agency, referred to as Management and Coordination Agency statistics below)
- United Kingdom: 2.9 billion dollars (1992, 362.5 billion yen)
- France: 1.7 billion dollars (1993, 184.0 billion yen)
- Germany[8]: 1.6 billion dollars (1993, 173.5 billion yen)

In contrast, technology imports (value paid) amount to the following:

- Japan: 7.2 billion dollars (1993, 798.1 billion yen) (Bank of Japan statistics)
- United States: 4.8 billion dollars (1993, 538.2 billion yen)
- Japan: 3.3 billion dollars (1993, 363.0 billion yen) (Management and Coordination Agency statistics)
- Germany: 3.0 billion dollars (1993, 338.2 billion yen)
- United Kingdom: 2.4 billion dollars (1992, 302.4 billion yen)
- France: 2.3 billion dollars (1993, 258.0 billion yen)

As a result, only the U.S. has a surplus in its technology trade balance. In 1993, the U.S. technology trade surplus was 15.6 billion dollars (1.730 trillion yen) and its ratio (export / import) was 4.21. The United Kingdom has a surplus and a ratio of 1.20 in 1992. France and Germany have a technology trade deficit, and their ratio were 0.71, 0.51 in 1993. In Japan, the technology trade deficit was 1.10, recording an excess of exports for the first time since the survey was initiated in 1972, with a favorable balance of trade of 37.4 billion yen, according to Management and Coordination Agency statistics. On

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[8] Data up to 1989 for Germany in chapter 3 is, as a general rule, data for former West Germany.

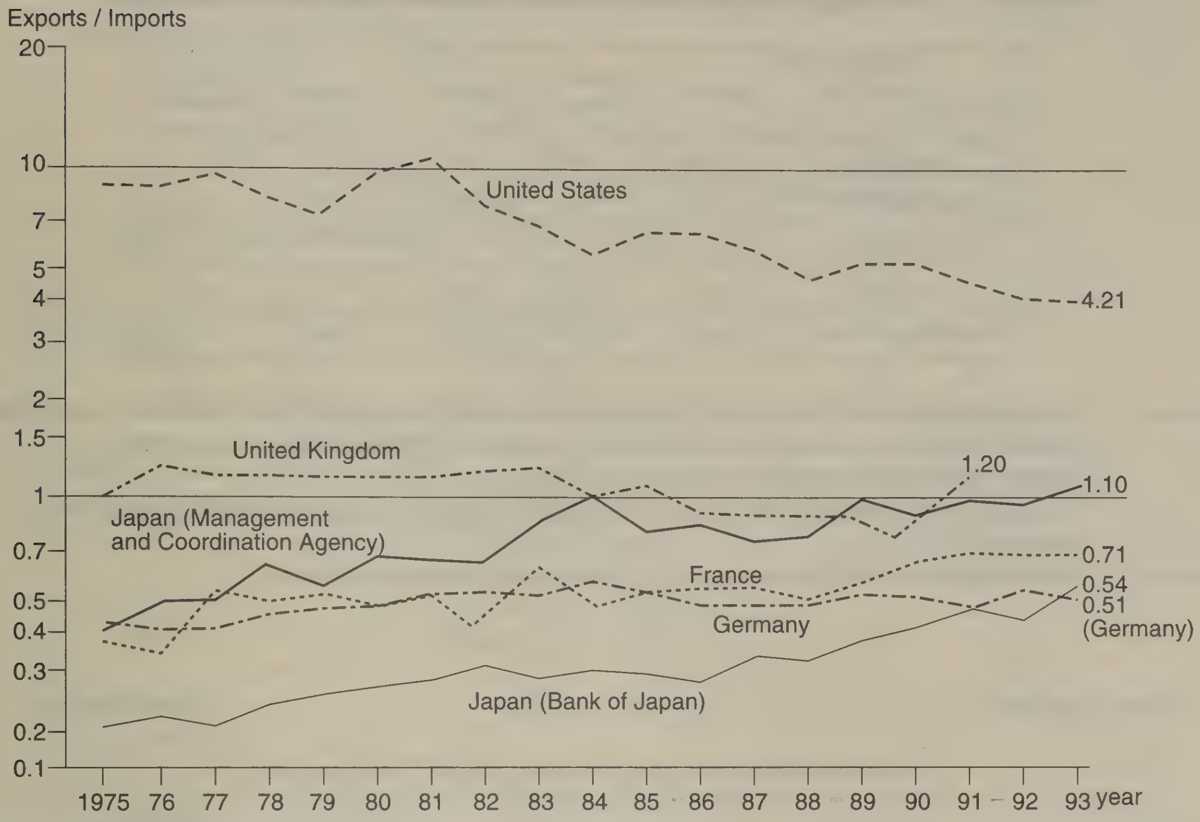

Figure 2-3-2 Trends in technology trade balance of selected countries

Note: Same as in Figure 2-3-1.
Source: Same as in Figure 2-3-1.
(See Appendix 11,12,13)

the other hand, according to Bank of Japan statistics, while Japan's technology trade balance ratio is becoming more balanced, still the technology trade deficit in 1993 was 367.0 billion yen, and the ratio at 0.54, indicating a large-scale deficit (Figure 2-3-2).

The technology trade balance between major countries shows the U.S. with an overwhelming surplus against the other countries. Japan has a surplus only with the United Kingdom (Table 2-3-3).

2.3.1.2 Japan's Trade in Technology with Other Countries and Regions

Japan's technology trade balance with major countries is improving in the long run with fluctuations in some years (Figure 2-3-4).

A look at the situation in FY 1993 by country and region shows that technology exports to Asia (excluding West Asia) were 186.4 billion yen, accounting for 47% of total exports. The breakdown by country is as follows:

- Korea: 50.4 billion yen
- China: 37.0 billion yen (including Taiwan, 20.7 billion yen)

Table 2-3-3 Technology trade balance between selected countries by counterpart

Technology trade counterpart / Country (Year)	Japan	United States	Germany	France	United Kingdom
Japan (1993)		0.46	0.51	0.66	2.19
United States (1993)	4.36		3.87	6.01	1.47
Germany (1993)	2.44	0.23		0.77	
France (1993)	4.00	0.25	1.62		0.50
United Kingdom (1992)	1.04	0.75	2.19	1.94	

Notes: 1. Each figure shows the technology trade balance (exports/imports) of each selected country with its trade counterpart based on each country's statistics. The figure for Japan is from Management and Coordination Agency statistics.

2. The figure for the ratio of Germany to France and Germany to UK indicater the value that of Germany to EC.

Source: Statistics of each country compiled by Science and Technology Agency.

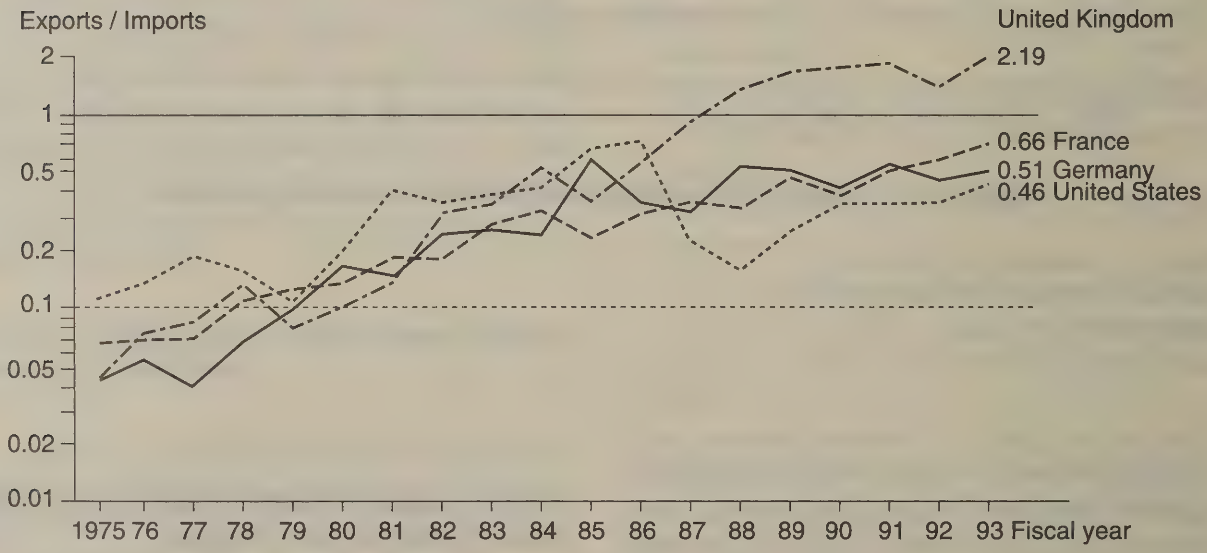

Figure 2-3-4 Trends in technology trade balance of Japan with other selected countries

Source: "Report on the Survey of Research and Development," by the Statistics Bureau, Management and Coordination Agency.

(See Appendix 13)

- Thailand: 32.5 billion yen
- Singapore: 24.8 billion yen
- Malaysia: 18.2 billion yen
- Indonesia: 11.9 billion yen

The United States stands as the largest importer of Japanese technology at 119.2 billion yen, accounting for 30% of the total.

Regarding technology imports into Japan,

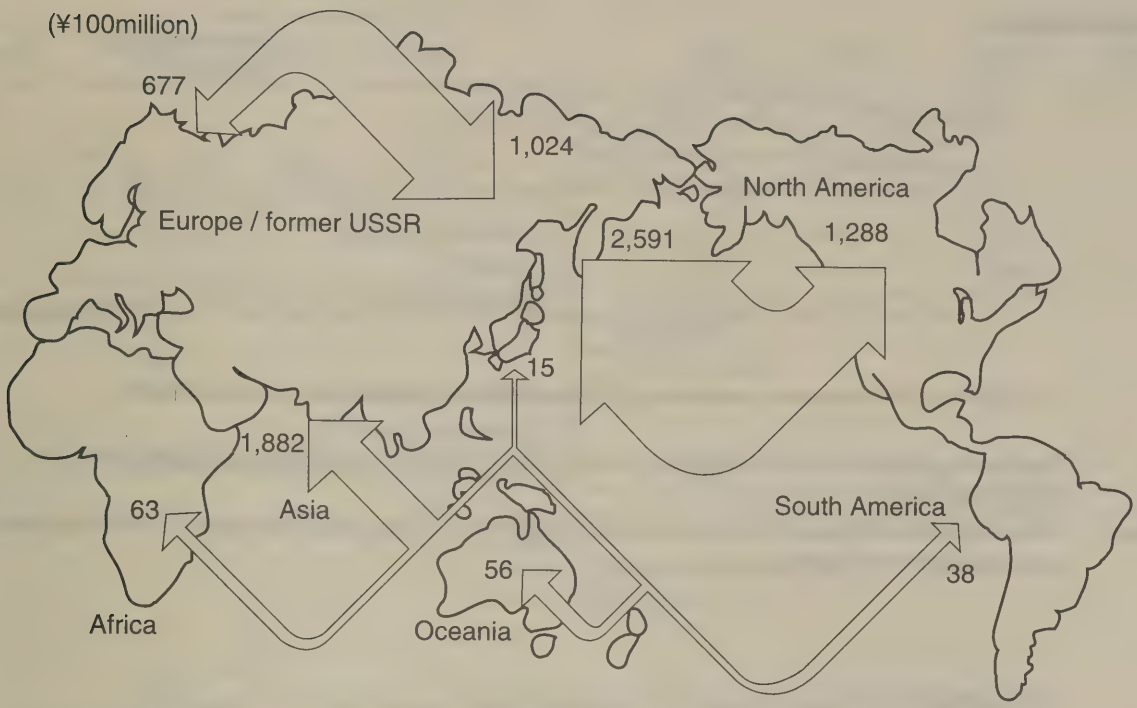

Figure 2-3-5 Trade in technology by region (FY1993)

Source: "Report on the survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 13,14)

North America and Europe play an overwhelmingly large role. Above all, technology imports from the United States in FY 1993 were 257.8 billion yen (a 11.8% decrease from the previous year) and 71% of Japan's total imports. After the United States, the following countries are significant (Fgure 2-3-5).

- Netherlands: 21.6 billion yen
- Germany: 18.8 billion yen
- France: 16.1 billion yen
- Switzerland: 15.8 billion yen
- United Kingdom: 14.0 billion yen

2.3.1.3 Trends of Japan's Trade in Technology

As described earlier, according to Bank of Japan statistics for 1993, Japan's technology exports were 431.1 billion yen, a 27.0% increase over the previous year (dollar based comparison), and imports were 798.1 billion yen, a 0.2% decrease from the previous year (same). These statistics indicate that the technology export / import ratio changed from 0.42 in 1992 to 0.54 in 1993. According to Management and Coordination Agency statistics, technology exports for FY1993 were 400.4 billion yen, a 20.8% increase over the previous year (same), and imports were 363.0 billion yen, a 0.2% decrease from the previous year (same). As a result, the technology trade balance ratio changed from 0.91 in the previous fiscal year to 1.10. It was the first excess of exports since the survey was initiated in 1972.

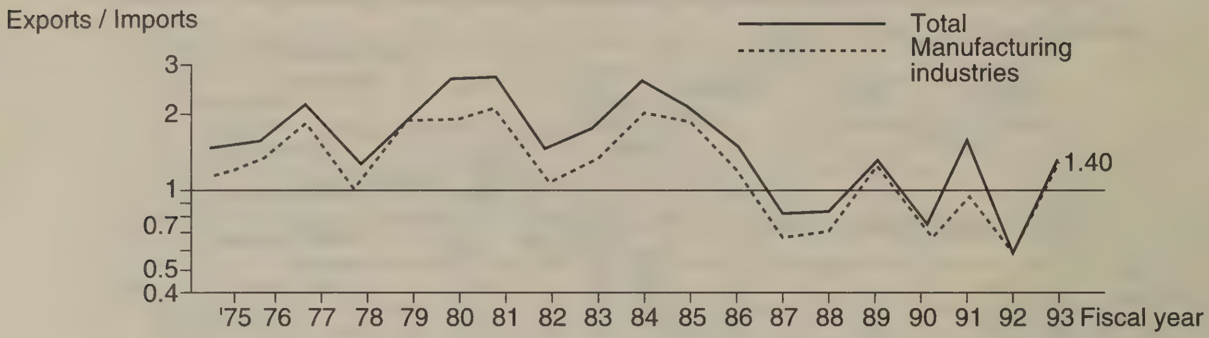

Figure 2-3-6 Trends in technology trade balance caused by new contracts

Note: "Technology trade in new contracts" refers to trade caused by newly made contracts in an applicable year.

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

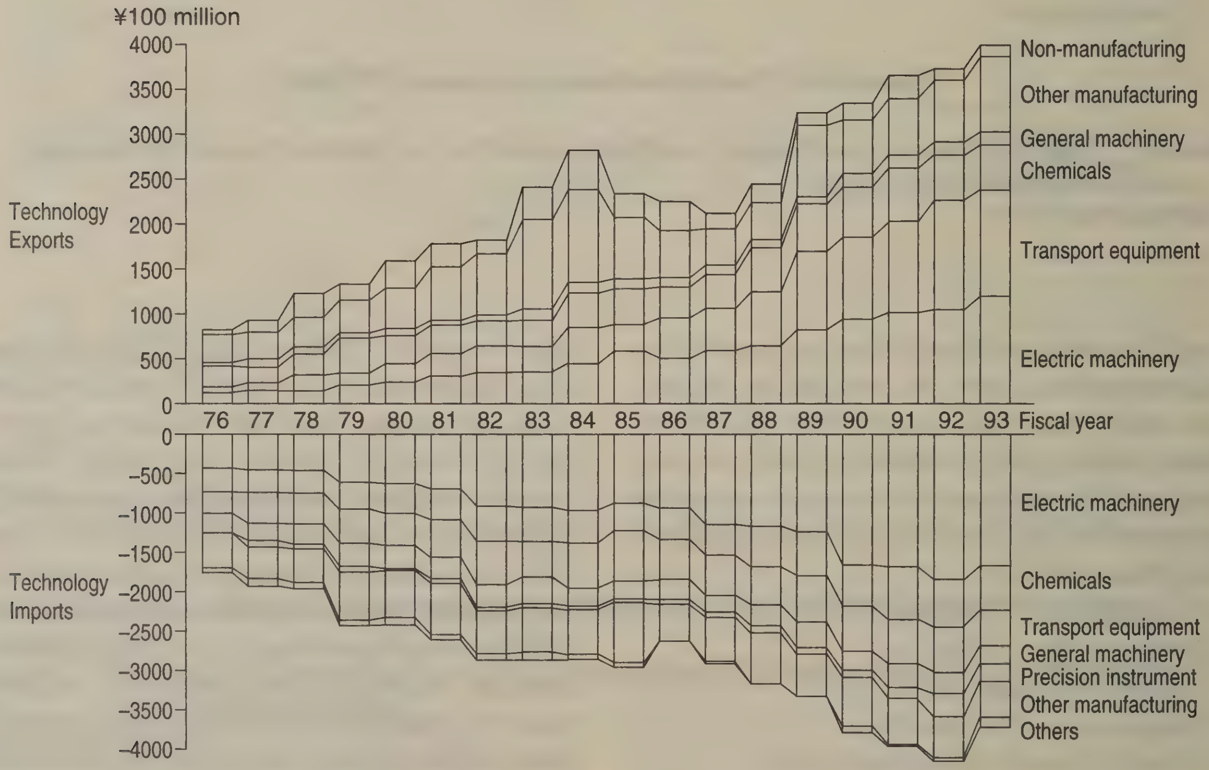

Figure 2-3-7 Trends in technology trade by industry sector

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 12)

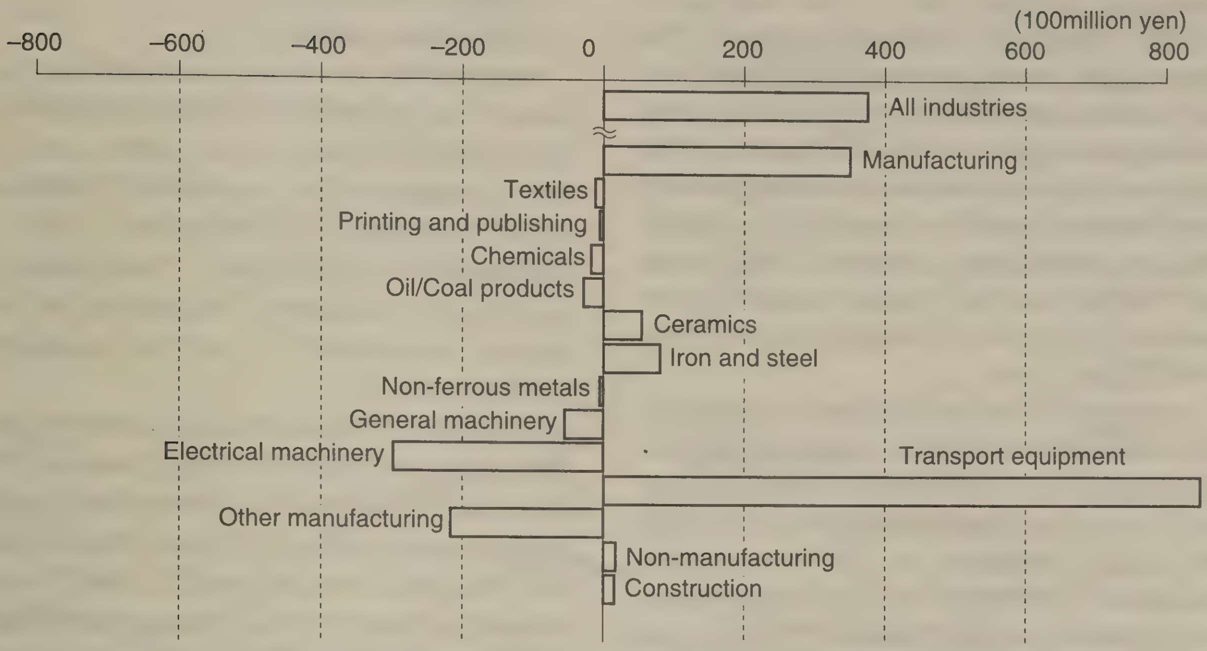

Figure 2-3-8 Technology trade balance by industry sector (FY1993)

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 12)

Technology trade data compiled by Management and Coordination Agency for FY1993 indicates that technology trade for new contracts (technology trade for contracts newly established in FY1993 only) resulted in an exess of 17.9 billion yen in exports. (Figure 2-3-6).

According to Management and Coordination Agency statistics, technology exports by industry sector in the manufacturing sector are as follows for FY1993:

- Transport equipment: 127.7 billion yen
- Electrical machinery: 127.4 billion yen
- Chemicals: 59.3 billion yen
- General machinery: 18.4 billion yen

These industries make up 84% of the manufacturing sector. Others include the following.

- Steel: 13.3 billion yen
- Ceramics: 9.8 billion yen

The following are FY1993 statistics of technology trade imports by industry sector (Figure 2-3-7).

- Electrical machinery: 159.2 billion yen
- Chemicals: 61.4 billion yen
- Transport equipment: 40.4 billion yen
- General Machinery: 25.6 billion yen
- Precision instruments: 22.7 billion yen

The following are major industry sectors in which technology exports exceed technology imports (Figure 2-3-8).

- Transport equipment: 87.3 billion yen surplus
- Iron and steel: 9.9 billion yen surplus
- Ceramics: 6.0 billion yen surplus
- Construction: 3.6 billion yen surplus

The surplus in the transport equipment industry is contributed mainly by the surplus in the motor vehicle industry.

Trade balance trends show that the transport equipment industry had its first surplus in FY1987. After that, it has been increased. The construction and the iron & steel industries have had surpluses of exports over imports since the second half of 1970s. The trade balance in the electrical machinery industry became gradually more balanced until the second half of 1980s, while the recent ratio is around 0.7 and changing. The deficit in the chemical industry has remained fairly steady in recent years, at 0.97 in 1993 (Figure 2-3-9).

According to National Institute of Science and Technology Policy of the Science and Technology Agency, the number of cases of new technologies being introduced into Japan was 3,029 in FY 1993, a reduction of 195 cases (6.0%) compared to the previous year. As for the various technology classifications, 98.8% (2,993 cases) of the total cases belong to manufacturing. The further breakdown are as follows:

- Electric machinery and appliances: 2,023 (66.8% of total)
- General tools and machinery: 221
- Chemical products: 164
- Clothing and textiles: 151

Introductions of electric machinery and appliances has increased 2.9 times compared to the number of cases 10 years before, and 1.5 times compared to five years before. However in all technology classifications, cases of introduction have decreased. Therefore, it is clear that introductions of technology are becoming concentrated in electrical machinery and appliances.

Introduction of technologies bas been mostly from the United States with 1,985 cases (65.5% of the total), followed by countries such as the United Kingdom with 195 cases, France with 161 cases and Germany with 147 cases. In advanced technology fields, computer-related technologies (1,609 cases) are dominant over other advanced fields. Software makes up the largest portion of these introductions with 1,517 cases, followed by hardware with 82 cases and service with 10 cases. (Figure 2-3-10).

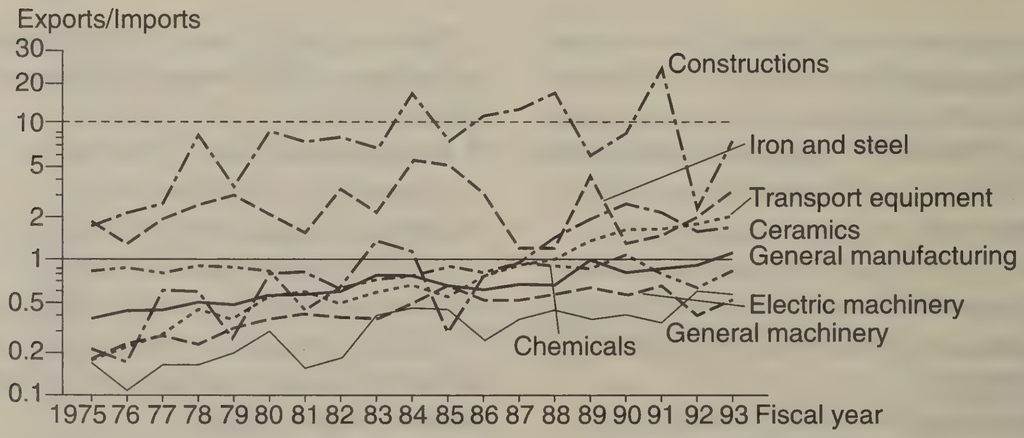

Figure 2-3-9 Trends in technology trade balance in major industry sectors

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.
(See Appendix 12)

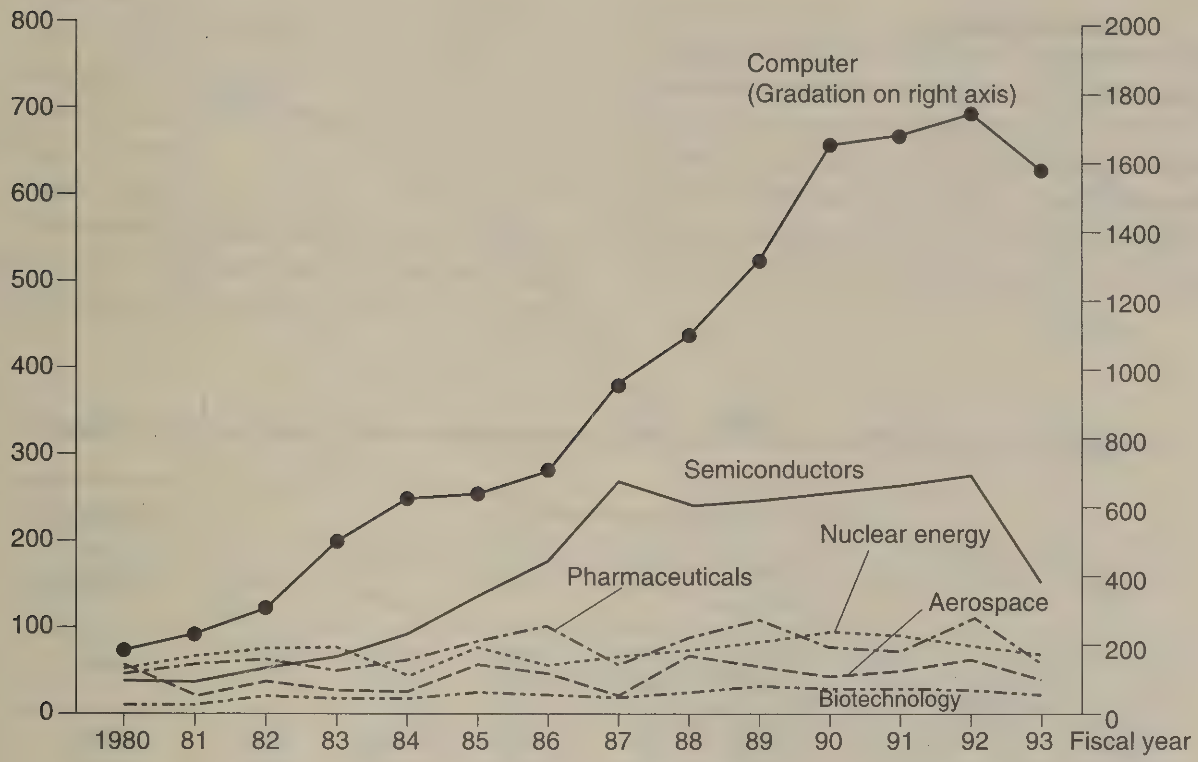

Figure 2-3-10 Trends in number of advanced technologies introduced into Japan

Source: "Analysis of Trends in Technology Imports (FY1993)" compiled by National Institute of Science and Technology Policy, Science and Technology Agency.

2.3.2 Patents

Countries in which a large number of patents are applied for are countries in which private corporations and other organizations carry out active R&D and great importance is attached to the protection of technologies: These countries can be considered to possess a great number of high technologies. Also, countries to which many patent applicants and inventors belong are those where R&D and inventions are actively being carried out.

2.3.2.1 Patents in Selected Countries (Trends in Application and Registration)

Looking at the number of patents applied for in selected countries (including Patent Cooperation Treaty (PCT) applications9) and European Patent Convention (EPC) applications10), Japan ranks at the top. The number of patents applied for in selected countries in 1991 follows:

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9) In 1978, the Patent Cooperation Treaty (PCT) went into effect, by which it became possible for the applicant to apply for patents in more than one country (designated countries) at the same time, when he presents one application at one place. The number of PTC member countries is 61, as of January 1994.

10) In 1977, the European Patent Convention (EPC) went into effect, and since June 1978, the European Patent Office (EPO) has been processing European patent (EPC) applications. When a European patent is granted after an examination by the EPO, the patent has the same validity in the other EPC member countries designated by the applicant. The number of EPC member countries is 17.

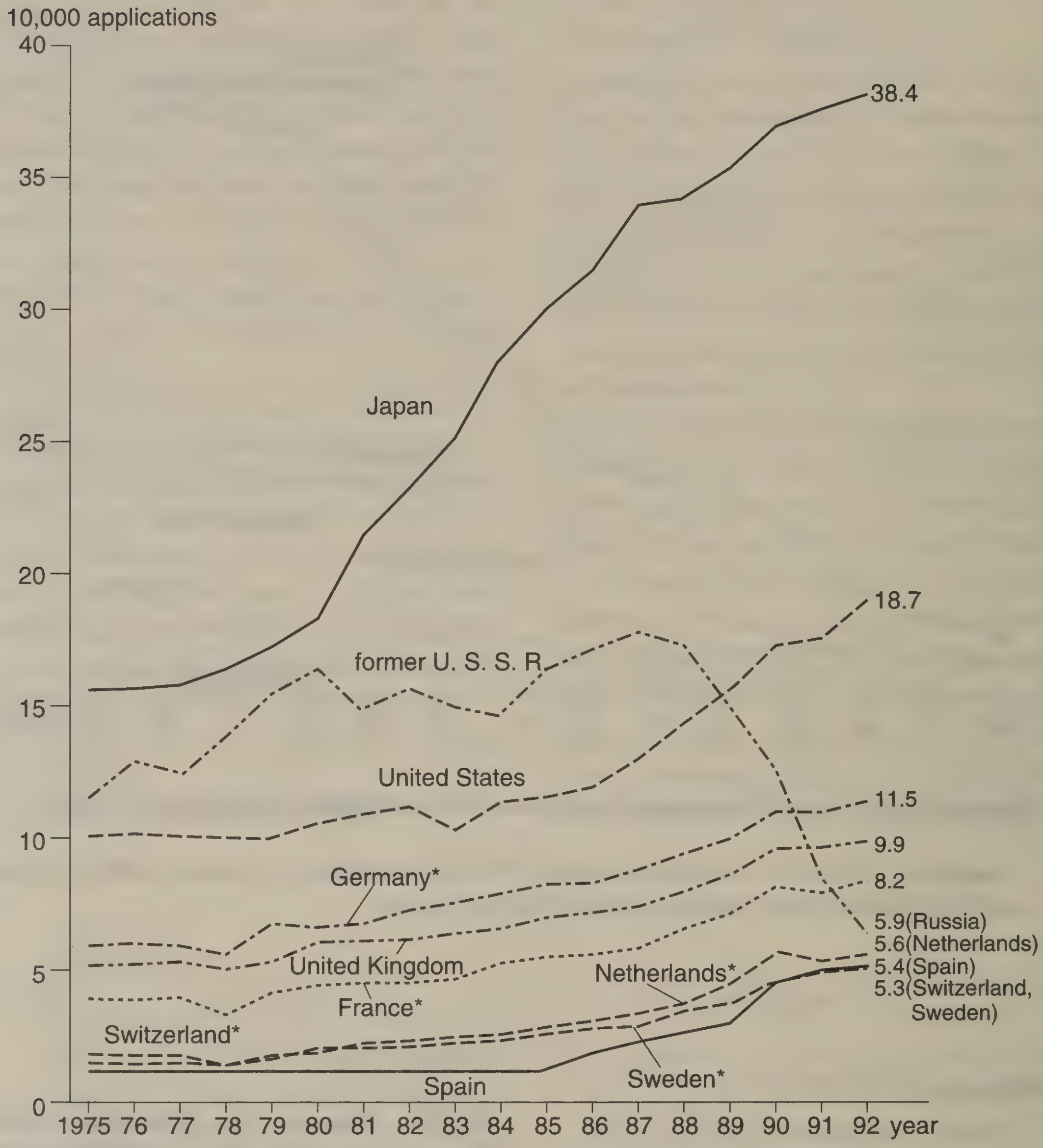

Figure 2-3-11 Trends in the number of patent applications in selected countries

Notes: 1. Numbers of applications include applications under the Patent Cooperation Treaty (PCT) and the European Patent Convention (EPC).
2. " * " indicates EPC member countries.
3. Data for the former Soviet Union and Russia until 1991 is from the Soviet Union and includes inventor's certificates, while 1992 data is from Russia. 1991 data is applies through 24 December.

Sources: "Industrial Property Statistics" compiled by the World Intellectual Property Organization (WIPO). European Patent Office statistics also were used between 1979-1984.

- Japan: 384,000
- United States: 187,000
- Germany: 115,000
- United Kingdom: 99,000
- France: 82,000
- Russia: 59,000

The number of patents applied for in the former U.S.S.R. decreased due to a large reduction in the number of inventors' certificates (Figure 2-3-11).

Regarding the nationality of patent applicants in selected countries, the ratio of foreign patent applicants is small in Japan (12.1%, in case of patents granted, 14.2%). In the United States, which has the largest number of patent applications by foreigners, the nationalities of patent applicant (1992) are as follows: (Table 2-3-12).

Table 2-3-12 Number of patent applications (granted patents) in selected countries (1992)

Nationality of applications	Country where patents were applied for							
	Japan	United States	Germany	France	United Kingdom	Italy	Nether-Lands	Others
Japan	338,107 (78,994)	40,267 (21,925)	14,501 (8,479)	11,264 (5,904)	12,826 (7,354)	5,717 (2,603)	4,480 (2,380)	40,041 (17,300)
United States	22,325 (6,080)	94,017 (52,254)	25,318 (8,006)	22,471 (7,442)	25,839 (8,347)	19,226 (5,626)	18,851 (4,809)	265,092 (48,065)
Germany	7,409 (2,762)	14,466 (7,311)	45,911 (17,833)	12,864 (8,138)	12,522 (7,739)	11,072 (6,678)	9,188 (5,034)	93,111 (32,401)
France	2,804 (928)	6,012 (3,029)	5,402 (3,189)	15,978 (8,462)	5,164 (3,028)	4,712 (2,801)	3,583 (2,169)	39,826 (15,759)
United Kingdom	3,195 (573)	7,040 (2,425)	5,265 (1,810)	4,459 (1,728)	24,092 (4,642)	4,115 (1,508)	4,526 (1,322)	64,891 (10,884)
Italy	1,143 (298)	2,659 (1,271)	2,740 (1,228)	2,579 (1,293)	2,585 (1,152)	9,153 (3,705)	1,732 (785)	20,829 (6,274)
Nether-Lands	1,553 (566)	1,830 (855)	2,475 (1,062)	2,338 (974)	2,559 (989)	1,973 (792)	3,866 (963)	36,816 (11,519)
Others	7,920 (1,899)	21,000 (8,373)	13,597 (4,913)	10,085 (4,274)	13,654 (4,576)	8,696 (3,515)	9,659 (2,884)	—
Total	384,456 (92,100)	187,291 (97,443)	115,209 (46,520)	82,038 (38,215)	99,241 (37,827)	64,664 (27,228)	55,885 (20,346)	—
Percentage of foreign nationalities	12.1 (14.2)	49.8 (46.4)	60.2 (61.7)	80.5 (77.9)	75.7 (87.7)	85.9 (86.4)	93.1 (95.3)	—

Notes: 1. Numbers in parentheses refer to granted patents.
2. These data include designated countries under the PCT and the EPC.
Source: "Industrial Property Statistics" by the World Intellectual Property Organization.

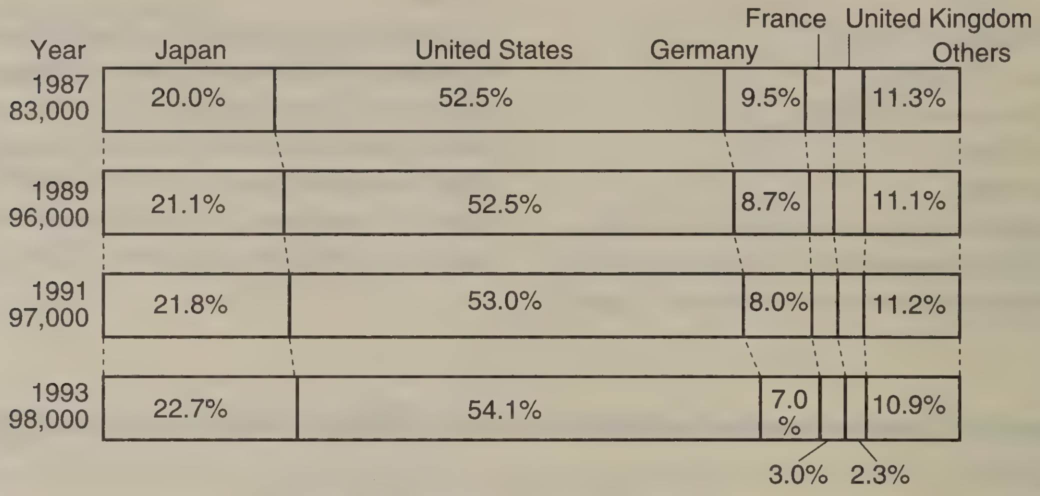

Figure 2-3-13 Breakdown of nationalities of granted patents by the United States

Note: Former East Germany is included in Germany.
Source: United States Patent and Trademark Office data.

- United States: 50.2%
- Japan: 21.5%
- Germany: 7.7%
- United Kingdom: 3.8%
- France: 3.2%

U.S.-granted patents by nationality of inventor (1993) are as follows: (Figure 2-3-13).

- United States: 54.1%
- Japan: 22.7%
- Germany: 7.0%
- France: 3.0%
- United Kingdom: 2.3%

2.3.2.2 Patent Applications by Japanese in Foreign Countries

In 1992, the number of patens that were applied for in foreign countries by Japanese citizens was 129,000 (including designations under the PCT and EPC applications), an decrease of 3,876 (2.9%) over the previous year. The following shows the countries where patents were applied for by Japanese (Figure 2-3-14).

- United States: 31.2%
- Germany:11.2%
- United Kingdom:10.0%
- France: 8.7%
- Korea:5.2%

The percentages of Japanese patent applicants in selected countries were as follows (Table 2-3-15).

- United States: 21.5%
- France: 13.7%
- United Kingdom: 12.9%
- Germany: 12.6%

2.3.2.3 Trends in Patent Application in Japan

The number of patent applications in Japan has been increasing. This is due to an improvement in the level of technology and to the impetus of active R&D. In 1993, the number of patent

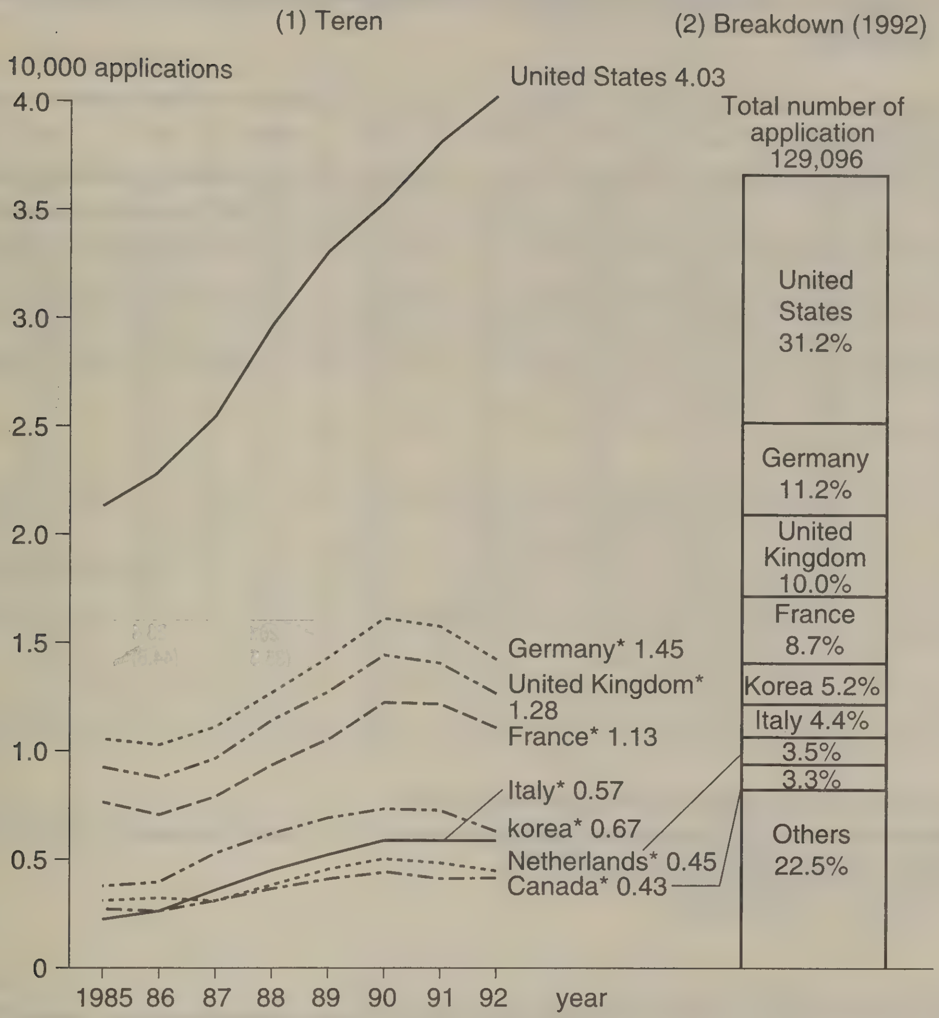

Figure 2-3-14 Trends in number of patent applications in foreign countries by Japanese

Notes: 1. Numbers of applications include applications under the Patent Cooperation Treaty (PCT) and the European Patent Convention (EPC).

2. "*" indicates EPC member countries.

Sources: "Industrial Property Statistics" by the World Intellectual Property Organization (WIPO).

applications was 366,000[11], a 1.5% decrease from the previous year. The number of applications for utility models was 77,000[11], a decrease of 18.5% from the previous year.

Numbers of patent applications in 1992[12] by technical classification are as follows (Table 2-3-16):

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[11] "Patent Agency Yearbook 1993" by Patent Agency.

[12] Technical classification of an individual application for a patent or utility model is done approximately one year after the application

Table 2-3-15 Changes in the ratio of Japanese in patent applications (granted patents) in selected countries

(unit: %)

Year Country	1980	1985	1986	1987	1988	1989	1990	1991	1992
United States	12.4 (11.6)	18.9 (17.8)	18.7 (18.6)	19.1 (20.0)	20.1 (20.7)	20.5 (21.1)	20.3 (21.6)	21.8 (21.8)	21.5 (22.5)
Germany	10.3 (11.4)	12.5 (14.4)	12.0 (14.6)	12.5 (15.1)	13.4 (15.5)	14.1 (16.3)	14.9 (17.4)	14.7 (18.1)	12.6 (18.2)
France	8.9 (6.7)	12.6 (11.7)	11.8 (12.6)	12.6 (12.2)	13.7 (12.5)	14.4 (13.1)	15.2 (13.6)	15.6 (14.3)	13.7 (15.5)
United Kingdom	9.6 (9.4)	12.6 (17.2)	11.9 (16.7)	12.5 (16.8)	13.5 (17.0)	14.3 (17.6)	15.0 (18.0)	14.9 (18.9)	12.9 (19.4)
Netherlands	8.3 (11.8)	9.3 (9.9)	8.0 (9.7)	8.6 (10.0)	9.1 (9.8)	9.5 (10.0)	9.7 (10.5)	9.6 (10.8)	8.0 (11.7)
Sweden	4.5 (4.6)	5.9 (6.3)	5.5 (6.6)	6.4 (6.3)	7.2 (6.5)	7.4 (6.4)	7.4 (6.7)	7.1 (7.2)	5.8 (7.7)
Switzerland	5.6 (6.2)	6.4 (7.9)	6.0 (7.0)	6.8 (7.0)	7.1 (6.5)	7.4 (6.6)	7.3 (6.7)	6.7 (7.7)	5.7 (8.1)
Korea	32.0 (44.4)	30.1 (35.8)	26.6 (44.5)	27.7 (41.6)	27.2 (35.1)	26.0 (35.5)	23.4 (44.8)	20.3 (46.3)	16.6 (41.4)
Canada	8.1 (7.8)	11.1 (10.9)	11.2 (11.3)	10.9 (10.7)	11.8 (11.9)	11.6 (12.8)	11.7 (12.7)	11.0 (13.1)	9.7 (13.9)

Notes: 1. Numbers in parentheses refer to granted patents.
2. Numbers of applications include applications under the Patent Cooperation Treaty (PCT) and the European Patent Convention (EPC).

Source: Same as in Figure 2-3-14.

Table 2-3-16 Number of patent application by technical classification in Japan (1992)

Technical classification	Number of application	(Composition rate %)	Breakdown of application by foreign	(%)
Daily commodities	21,220	(6.2)	2,241	(10.6)
Processing, operations, transportions	63,525	(18.4)	4,226	(6.7)
Chemicals, metals, textiles	45,638	(13.2)	6,417	(14.1)
Construction	12,002	(3.5)	300	(2.5)
Mechanical engineering	26,100	(7.6)	1,917	(7.3)
Physics	91,189	(26.4)	4,557	(5.0)
Electricity	85,186	(24.7)	4,329	(5.1)
Total	334,860	(100.0)	23,987	(7.0)

Source: Data are compiled by Science and Technology Agency from "Patent Agency Yearbook" by the Patent Agency.

- Physics: 91,000 (26.4% of the total applications)
- Electricity: 85,000 (24.7%)
- Processing, operations, transportation: 64,000 (18.4%)

The number of patent applications by foreign inventors has remained basically stable in recent years, with a 0.8 % increase to 34,000 cases in 1993 (9.3% of total applications). A breakdown of patent applications by the nationality of inventor is as follows (Figure 2-3-17):

- United States: 49.1%
- Germany: 14.5%
- France: 5.8%
- United Kingdom: 5.0%

A breakdown of patent applications by foreign inventors in 1992 by field is as follows (Table 2-3-16):

- Chemicals, metals, textiles: 14.1%
- Daily commodities: 10.6%
- Mechanical engineering: 7.3%
- Processing, operations, transportation: 6.7%

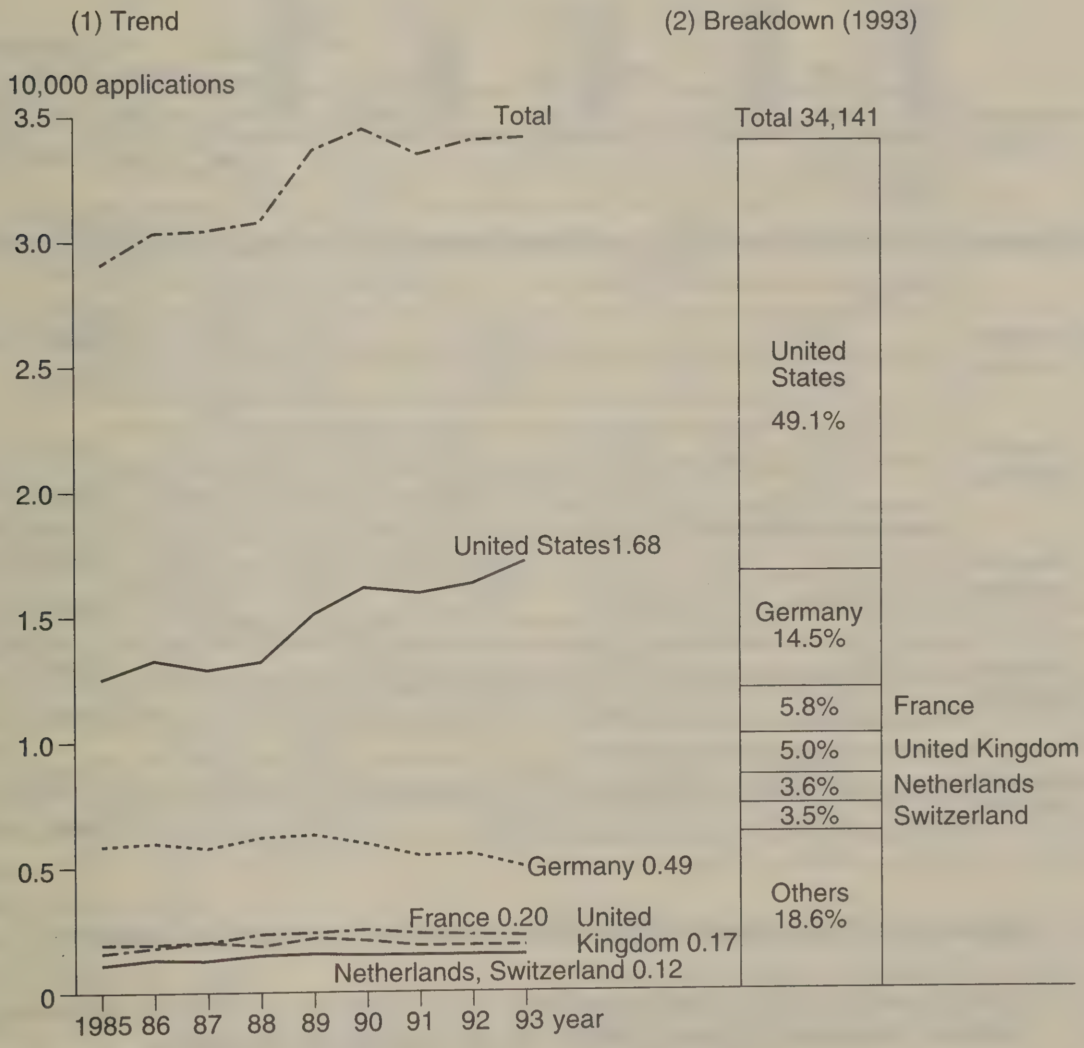

Figure 2-3-17 Number of patent applications by nationality of foreign inventors

Source: "Patent Agency Yearbook" by the Patent Agency.

2.3.3 High-Tech Products[13]

High-tech products require large investments in R&D as well as sophisticated technology during their manufacturing process. The production of high-tech products manufactured in all the OECD countries is growing at a faster rate than that of all manufactured goods. The amount manufactured in 1992 was 1.4 times greater compared to 1982, and 1.2 times greater compared to 1987. On the other hand, the amount of the high-tech products manufactured in 1992 was 3.9 times greater compared to 1982, and 1.7 times greater compared to 1987 (1980 dollar-based comparison).

In 1992, the United States had the largest production share of high-tech products manufactured by country at 37.2%, followed by Japan (27.9%), Germany (10.2%), the United Kingdom (6.6%) and France (5.2%). The share of Japan and the U.S. has increased over this 5-year peri-

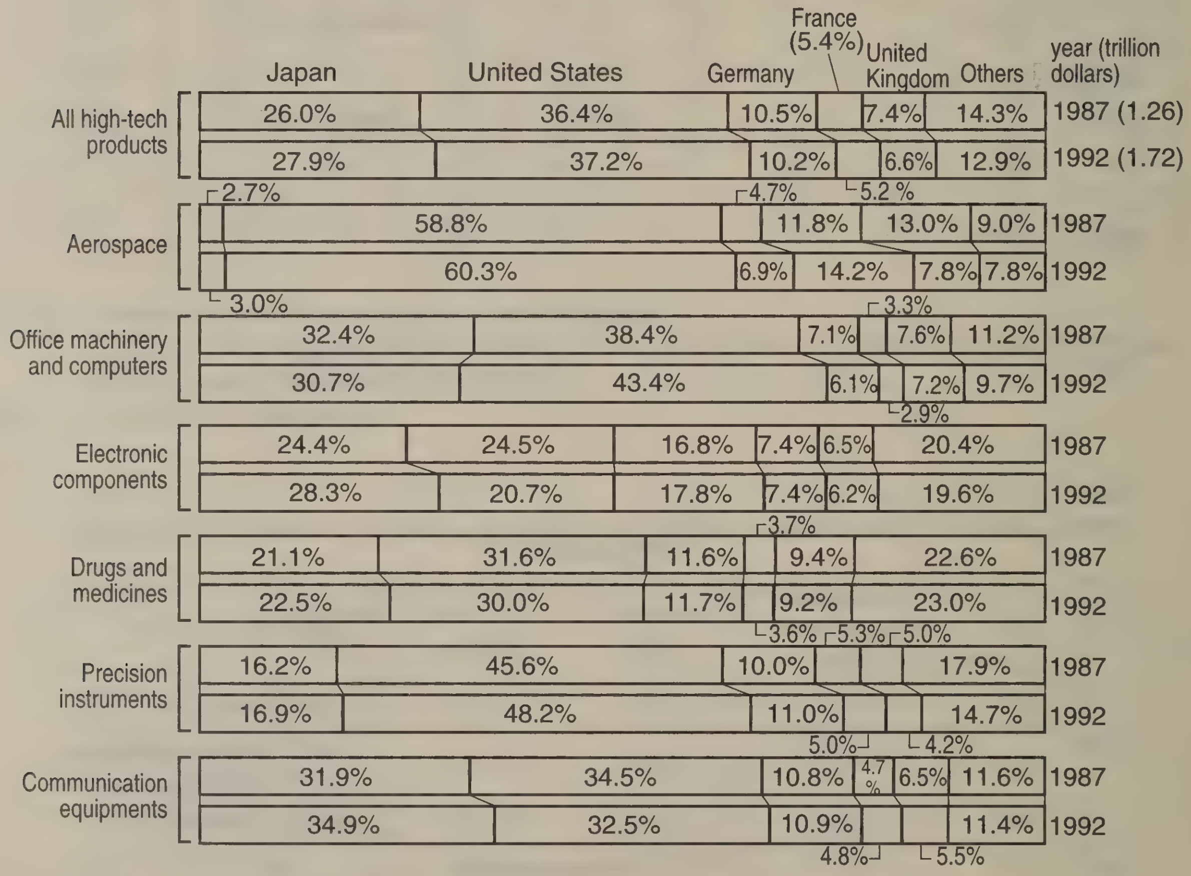

Figure 2-3-18 Share of high-tech products by country manufactured in OECD

Notes: 1. Figures based on 1980 dollar-based amounts. Figeures for 1990 are estimates.
Source: "Science & Engineering Indicators 1993" by the US National Science Board.

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13) At the OECD, the ratio of R&D expenditures to production is calculated by industry sector and classification into high-tech, mid-tech, and low-tech is done according to the size of value.

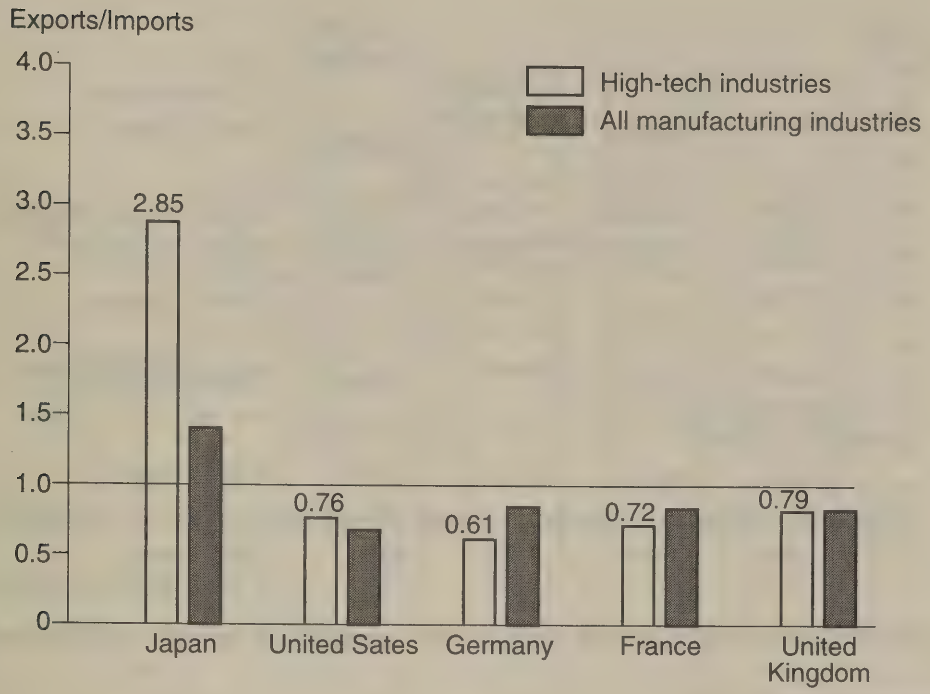


Figure 2-3-19 Trade balance of high-tech industries and all manufacturing industries (1992)

Note: Same as in Figure 2-3-18.
Source: Same as in Figure 2-3-18.

od. By industry, communication equipments (34.9%) and office machines/computers (30.7%) and electronic components (28.3%) have high shares in Japan (Figure 2-3-18).

Regarding the trade balance of high-tech products in 1992, only Japan had a surplus with a ratio of 2.85 among selected countries (Figure 2-3-19).

The share of export market for high-tech products (1992) is as follows:

- Japan: 23.5%
- United States: 18.3%
- Germany: 12.0%
- United Kingdom: 10.8%
- France: 7.8%

It can be seen that Japan's share has been growing since 1980 (Figure 2-3-20).

2.3.4 Scientific Papers

Scientific papers are the achievements of R&D. It is impossible to make a simple comparison between scientific papers because of qualitative differences, the regionality of the research subjects, the language normally used by the researchers and the language they are written in, etc. However, here is a comparison of the number of scientific papers published by each country.

The share by country of the number of scientific papers published in major scientific journals around the world in 1991 is as follows:

- United States: 35.1%
- Japan: 8.5%
- United Kingdom: 7.5%
- Germany: 6.8%

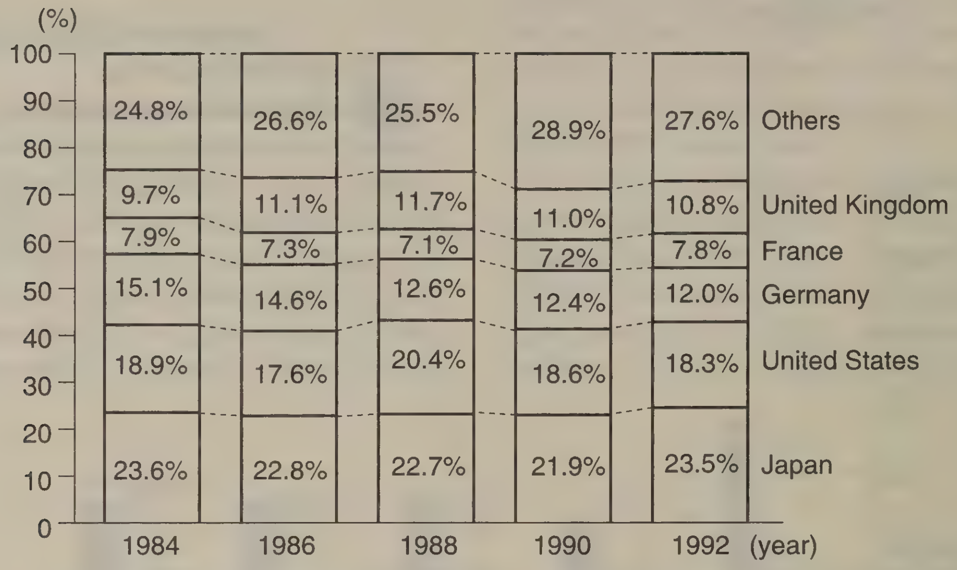


Figure 2-3-20 Export market shares for high-tech products by country in OECD countries

Note: Same as Figure 2-3-18.
Source: Same as Figure 2-3-18.

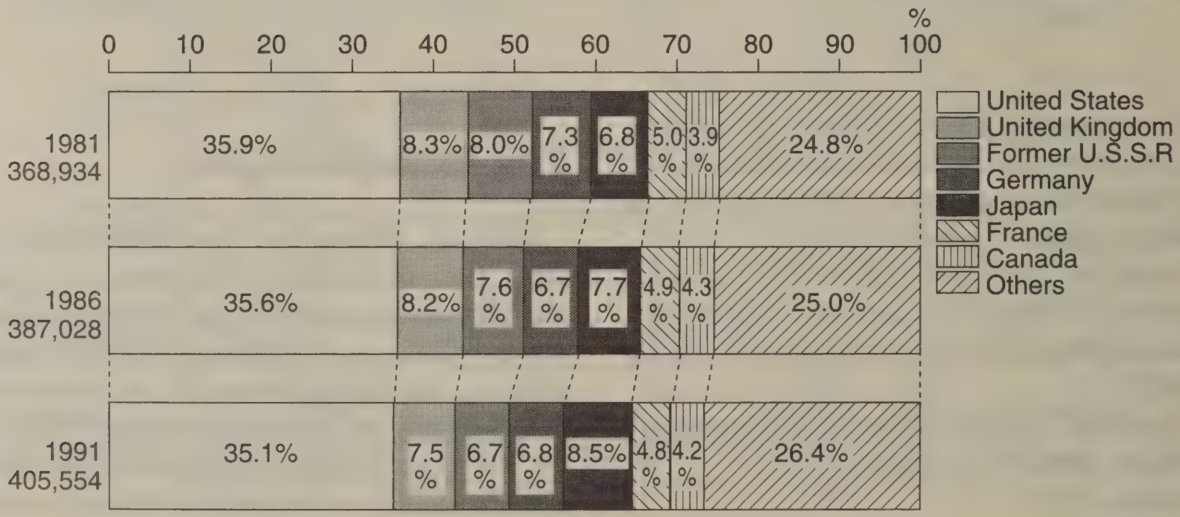


Figure 2-3-21 Share of the number of scientific papers published in major scientific journals by country

Source: "Science & Engineering Indicators 1993" by the US National Science Board.

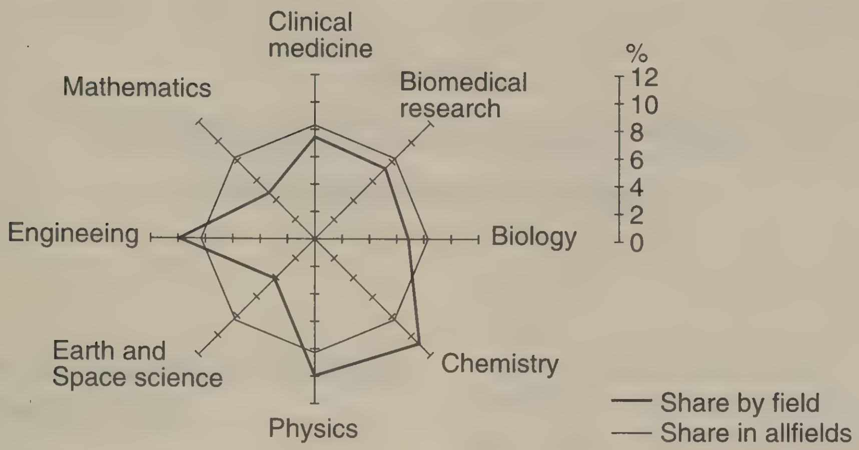


Figure 2-3-22 Share of scientific papers produced in Japan by field (1991)

Source: Same as in Figure 2-3-21.

- Former U.S.S.R. 6.7%

Only Japan has increased its share among the selected countries when compared to the share by country in 1981, and moved from 5th to second in the number of scientific papers it has contributed to publications worldwide (Figure 2-3-21).

When looking at the number of scientific papers published by field, it is apparent that the Japan's share of chemistry, physics and engineering is much larger than its share of the total number of scientific papers published. This shows that research in these fields is relatively active (Figure 2-3-22).

Part 3
Science and Technology Policy Development in Japan

3.1 General Guideline for Science and Technology Policy

In March 1986, the government approved The General Guideline for Science and Technology Policy in the Cabinet, based on a recommendation submitted by the Council for Science and Technology (CST), and since then, has been making efforts to promote Japanese science and technology with an emphasis on creativity in order to make the quality of national life more affluent.

The prime minister consulted the Council for Science and Technology in June 1990 regarding a comprehensive basic policy for science and technology to be adopted for the next 10 years in view of anticipated changes in the state of affairs in the coming century, and a report was put together in January 1992. The government approved The General Guideline for Science and Technology Policy in the Cabinet in April 1992 based on this report.

The basic concept of The General Guideline, in view of the coming century, is to make contributions to international society and humanity as a whole, utilizing and increasing Japan's economic strength and high level of technology. It provides for the following goals as a means to promote an active and comprehensive science and technology policy:

- Coexistence of humans in harmony with the Earth
- Expansion of intellectual stock
- Construction of a charming society where people can live with peace of mind

The government has a major role in achieving these goals. The universities and national research institutes which are largely responsible for basic research, where researchers are trained and which are at the core of international science and technology activity, have to deal with low research funds, out-of-date facilities and equipment, lack of personnel, the aging of researchers, and other issues. Therefore, it has become imperative for the government to increase its investment in R&D to improve the research environment of Japan's universities and national research institutes without delay.

In order to realize these goals, the government will promote the following measures:

- Harmonization between science/technology and humans/society
- Securing scientific and technological personnel
- Increase of R&D Investment
- Intensification of the R&D Infrastructure
- Activation of research and improvement of creativity
- Intensification of international science and technology activities
- Promotion of science and technology in regions

In The General Guideline, the research fields which should be given special priority in being promoted are listed along with the 3 goals and 7 priority measures mentioned above.

General Guideline for Science and Technology Policy

I. BASIC PRINCIPLES

For humans to construct a stable and a more prosperous 21st Century, it is absolutely necessary to further promote science and technology in consideration of harmony with humans/society and the environment. Especially, in Japan, where humans are its largest resource, future prosperity is heavily dependent on science and technology.

Realizing this and recognizing that Japan should contribute to the international society and humans as a whole, the government strives to develop a positive and comprehensive policy on science and technology with the following three points as its goals.

* *Coexistence of humans in Harmony with the Earth:* Japan will aim at solving various issues such as global environment issues, energy issues and food issues, constructing a stable international order and settling the north-south problems.

* *Expansion of Intellectual Stock:* Japan will accumulate well-balanced high-quality scientific knowledge including results of basic research so that all humans will be able to benefit.

* *Construction of a Charming Society Where People Can Live with Peace of Mind:* Japan will make the quality of national life more affluent, while coping with social issues such as the sharp increase in the number of old people.

II. PRIORITY MEASURES

To improve and intensify schemes and conditions for promoting science and technology, the government will promote the following measures, while establishing basic guidelines for implementing the priority measures. Especially, awaring diverse and important roles of universities and national/public research institutes, their R&D ability and the ability of cultivating human resources should be drastically intensified with necessary reviews.

1. Harmonization between Science & Technology and Humans/Society

Recognizing that science and technology deeply affects every part of life and society, and it should exist for the sake of humans/society, in order to allow for harmonization between S&T and humans/society, the government will:

1) * make efforts to improve safety and adaptability to humans/society of the technologies which are already practically applied and exist;

* assess the influence of new technologies on humans/society from various aspects, and if necessary, make efforts to present the results to the people in an easy to understand way; and

2) * cultivate an environment in which the people can more easily understand science and technology and use it effectively, by increasing the chances of lifelong integrated learning about science and technology, improving facilities including science museums, and strengthening activities of dissemination and enlightenment.

2. Securing Scientific and Technological Personnel

Since human resource is the key for promoting science and technology, in order to increase the number of engineers, researchers and research assistants and improve their quality, the government will:

1) * make efforts to bring up its youth with more feeling and interest in science and technology by increasing the chances to have actual experiences very important for cultivating scientific interest, for example, by placing emphasis on observations and experiments in primary/secondary education, and to rise the attraction of scientific and technological occupations by improving their

treatment and working environment;

2) ＊intensify the educational function of universities and colleges organically and systematically in order to further stimulate and educate personnel;

＊ for graduate schools, make efforts to increase the number of students in master courses, and to fill and increase the number in doctor's courses by further intensifying the economical assistance to the students of the doctor's courses, improve the education/research organizations, and increase the education/research funds;

3) ＊improve the environment to allow females to easily continue science and technology activities, for example, by eliminating the difference between males and females in chances and treatment, and by diversifying the working style during the periods of childbirth and childcare;

＊ improve the environment to allow elderly people to continue their work depending on their ability; and

4) ＊make efforts to increase the staff in universities and national research institutes and to correct their age structure, while making the occupation attractive by improving their treatment and research infrastructure.

3. Increase of R&D Investment

Since the national R&D ability greatly depends on the accumulated knowledge/technologies and R&D infrastructure formed by R&D investment, Japan should continuously maintain its R&D investment.

The R&D investment of Japan as a whole achieved the target level indicated in the 11th Recommendation of the Prime Minister's Council for Science and Technology (1984), being one of the factors which has greatly improved the level of science and technology in Japan. On the other hand, basic research is not making as much progress as had been expected and various kinds of trouble are surfacing. Therefore, by giving priority to the measures and R&D indicated in this Basic Policy, the government will transform Japan's R&D investment structure, from one with a high ratio of investment for R&D in order to secure competitiveness, into a balanced one.

In the process of the transformation of investment structure, while continuing efforts for improving the institutions and environment to support the further increase in R&D investment by the private sector, the government will make efforts to double its own R&D investments as early as possible, taking account of financial conditions.

4. Intensification of R&D Infrastructure

In order to intensify the R&D infrastructure to meet the advancement in science and technology and the increase in its scale, the government will:

1) ＊systematically renew the facilities and equipment of universities and national research institutes which are remarkably superannuated or out-of-date, as soon as possible;

＊ install facilities/equipment indispensable for conducting leading and advanced research at universities and national/public research institutes; open more widely to industrial, academic and governmental researchers and also to overseas researchers; promote joint use;

2) ＊substantialize the development, preservation and supply of apparatuses, raw materials, standard materials and genetic resources, etc.; and

3) ＊expand the production and the distribution of S&T information by facilitating the distribution of literature information and encouraging the construction and utilization of fact databases.

5. Activation of Research and Improvement of Creativity

In order to complete a flexible and competitive research system which can stimulate research including basic research and allow the creativity of researchers to be improved, and to foster an excellent research environment which will attract excellent researchers from all over the world, the government will:

1) ＊increase the mobility of researchers by improving institutions for promoting the research exchanges among the industrial, academic and governmental circles and with foreign countries;

＊ enlarge the chances of communication among researchers from various fields;

2) ＊expand various types of research funds offered under a competitive system and promote smooth deployment of these funds by national research institutes, while increasing ordinary research funds as the foundation of research activities;

＊ promote the deployment of funds and commodities from private enterprises;

3) ＊promote the intensification of research assistance system and the simplification of office work in order that researchers can be engaged more exclusively in R&D;

4) ＊promote to employ persons, including foreigners, excellent in research ability and leadership as research managers and planners;

5) ＊promote freedom of researchers on condition that appropriate evaluations are made;

＊ promote better treatment of brilliant researchers based on a proper evaluation; and

6) ＊establish diverse types of centers of excellence (which refer to core research functions with prominent research leaders, up-to-date research information, excellent facilities/equip ment, and substantial research assistance) by concentrating research resources such as staff members and funds.

6. Intensification of International Science and Technology Activities

In order to intensify international activities, considering Japan's position in international society, the government will:

1) ＊promote international collaborative R&D;

＊ propose and lead international collaborative R&D adopting original idea of Japan;

＊ improve the environment required for promoting the international collaborative R&D;

2) ＊examine how Japan should cope with each project of "mega-science" (which refers to projects absolutely requiring international cooperation because participation of researchers/engineers from a wide range of areas and very large or complex facilities are necessary) with subjectivity in reference to the discussion among researchers/engineers and Japan's research potential, paying attention not to cause pressure to other R&D activities while it is being promoted;

＊ make efforts to form internationally common recognition of "mega-science";

3) ＊take following action to expand science and technology cooperation for developing countries based on the concept that cooperation suitable for the situation of each country should be extended mainly for creating human resources as an aid to fructify their own efforts;

a) ＊Expansion of the chances of dialogues to identify developing countries' needs for cooper ation.

＊ Intensification of the function of clearing houses which provide information concerning S&T in developing countries and Japan.

b) ＊Expansion of the technical assistance in the official development aid such as the reception of trainees and dispatch of experts and improvement of effectiveness of the cooperation by intensifying liaison with fund assistance.

c) ＊Continuous and systematic expansion of the research cooperation and intensification of cooperation in cultivating human resources with the countries in regions including Asia Pacific region, which aim at improving their own R&D ability and have to cope with a variety of scientific and technological issues.

d) *Security of the close liaison between research cooperation and technical/fund assistance in efforts to implement cooperation effectively.

4) *extend research cooperation and, as required, technical assistance for the former Soviet Union etc. to support the reform to develop a market economy;

5) *establish an internationally opened research scheme by promoting the employment/acceptance of foreign researchers and by smoothing their activities in Japan, while implementing training on the Japanese language and expanding fellowship, and so on;

* expand the chances of dispatch of Japanese researchers and administrators to foreign countries;

6) *expand the international distribution of S&T information; and

7) *promote the international transfer of S&T by making efforts to standardize the protection level of intellectual property and other areas concerned with S&T.

7. Promotion of Science and Technology in Regions

Since S&T activities in regions are the motive power of regional activation, and they contribute to the formation of decentralized national land, and improve the quality of daily living of their inhabitants, in order to promote S&T regionally, the government will:

1) *support any promotion by local governments such as the establishment of S&T policies, the intensification of S&T promoting functions, the fostering of research institutes and testing stations, the intensification of liaisons between regional entities;

2) *support the regional activities to grow youth by the improvement of science museums, and soon;

3) *construct fundamental and leading research facilities in regions;

* develop the S&T information network;

* promote various types of research exchanges with universities and national/public research institutes in efforts to assist and stimulate those who are engaged in S&T regionally;

4) *let universities and national/public research institutes make efforts to lead basic research and other R&D in regions where they are located; and

* promote R&D which, for example, utilizes regional characteristics or which is closely related with the living of the inhabitants, in cooperation with regional entities while utilizing R&D coordination function of universities and national research institutes as required.

III. BASIC SCIENCE AND MAJOR R&D

1. Promotion of Basic Science

The government will promote basic science which is intended to discover new phenomena, to construct original theories for elucidating them, and to forecast unknown phenomena, since it expands the intellectual frontier of humans, forms the foundation for creating new views of nature, gives hope to the people, and suggests new ideas and guidelines for the science and technology of the next generation.

2. Promotion of Major R&D

The Government will energetically and effectively conduct or support following major R&D under proper research evaluation, while establishing or reviewing R&D basic plans.

1) fundamental and leading science and technology

a) Material science and technology

b) Information/electronics science and technology

c) Life science and biotechnology

d) Soft Science and technology

e) Advanced fundamental science and technology

f) Space science and technology
g) Ocean science and technology
h) Earth science and technology
2) Science and technology for human coexistence
a) Preservation of the natural environment including global environment
b) Development and utilization of energies
c) Development and recycling of resources
d) Continuous production of foods
3) Science and technology for enriching life and society
a) Maintenance and improvement of health
b) Improvement of living environment
c) Improvement of socioeconomic foundation
d) Strengthening of disaster-preventive and safety measures

3.2 The Council for Science and Technology

The Council for Science and Technology (CST) was established in February 1959 to comprehensively promote overall science and technology policies of the government. Under the terms of the establishment Law of the Council for Science and Technology, the CST is an advisory body to the Prime Minister supervised by the Prime Minister's Office. It is chaired by the Prime Minister and its members include cabinet ministers dealing with science and technology and distinguished experts in various fields. The CST's main task is to advise the Prime Minister in the following:

- Establishment of general basic science and technology policy (Those related only to cultural sciences are omitted. Same below.)
- Establishment of comprehensive long-term research goals
- Formulation of basic measures to promote essential research areas

These are especially important aimed at achieving these goals. The CST recommends findings on inquiries to the Prime Minister and, when appropriate, submits CST-initiated advice (Table 3-2-1).

The CST Committee on Policy Matters, composed of distinguished experts from various fields, manages important matters in a timely and appropriate manner and designs and develops flexible science and technology policy. The tasks of the Committee are as follows.

- Decide the direction for discussions on a recommendation
- Set the guidelines for expenditures of the Special Coordination Funds for Promoting Science and Technology
- Decide priorities for promoting science and technology
- Direct basic investigations to formulate science and technology policies

Table 3-2-1 Outline of major recommendations by the Council for Science Technology

Title	Date	Outline
Recommendation for Inquiry No. 9 "Basic Plan for R & D on Disaster Prevention"	July 6, 1981	In order to prevent disasters due to meteorological phenomena, control the expansion of damage in case disasters have occured and achieve recovery from disasters, the recommendation suggests the R & D areas and objectives concerning disaster prevention science and technology to be strongly promoted for a long period by the initiative of the government.
Recommendation for Inquiry No. 10 "Basic Plan for R & D on Life Science"	April 24, 1984	In order to develop more comprehensively, systematically and efficiently those technologies rapidly progressing in recent years which manipulate so-called genetic information systems of organisms such as DNA recombination and cell fusion, the recommendation suggests the R & D areas and objectives to be emphasized for the time being and the promotion measures to achieve the objectives.
Recommendation for Inquiry No. 11 "Comprehensive fundamental policy for promotion of science and technology to cope with current changing situations from a long-term point of view"	November 27, 1984	In order to comprehensively develop science and technology which will serve as the basis of a new culture and civilization in anticipation of the 21st century, the recommendation suggests general guidelines as a basis and management method for the science and technology policy for the next 10 years and with the following as basic cornerstones: • Promoting highly creative science and technology • Developing science and technology in harmony with man and society • Emphasizing the international aspect of science and technology
Recommendation for Inquiry No. 12 "General guideline for science and technology policy"	December 3, 1985	The recommendation specifies the content of the "general guideline for science and technology policy" which forms the basis of the policy for promoting science and technology. This recommendation ranks the promotion of science and technology based on the concept of' "promoting highly creative science and technology" as a fundamental policy guide and calls for policy development focused on the support of basic and pioneering science and technology. Further, the Cabinet approved the general guideline in March 1986.
Recommendation for Inquiry No. 13 "Intermediate and long-range basic policy for national research institutes"	August 28, 1987	Taking into consideration the changes in conditions surrounding national research institutes and the problems which they are facing, the recommendation suggests desirable medium- and long-term prospects for their future roles and ways to activate these roles.
Recommendation for Inquiry No. 14 "Basic plan for R&D on Materials science and technology"	August 28, 1987	In order to contribute to the comprehensive and systematic promotion activities in the future concerning materials science and technology, which had been rapidly progressing in recent years, the recommendation suggests significant R&D objectives and promotion measures for the next 10 years.
Recommendation for Inquiry No. 15 "Basic plan for R&D on information / Electronics science and technology"	March 14, 1989	With respect to information/electronics science and technology which have been rapidly progressing in recent years, the recommendation suggests expectations of this sort of science and technology, significant R&D tasks and promotion measures for the next 10 years.
Recommendation for Inquiry No. 16 "Comprehensive basic policy for upgrading and strengthening the infrastructure to support science and technology"	December 5, 1989	With respect to production and distribution of science and technology information, development, installation and provision of instruments and equipment and development, storage and supply of materials, genetic resources, etc., as well as research supporting functions as an environmental condition for activating fundamental activities and intellectual properties, the recommendation suggests the fundamental guidelines for constructing the infrastructure to support science and technology.
Recommendation for Inquiry No. 17 "Basic plan for R&D on earth science and technology"	June 22, 1990	The recommendation suggests basic concepts and important R&D topics with the aim of promoting R&D in earth science technology in Japan as a whole and indicates the role that the government should have and the measures it should implement in promoting R&D.
Recommendation for Inquiry No. 18 "Comprehensive and Basic Science and Technology Policy toward the New Century"	Junuary 24, 1992	This report outlines the science and technology policies that Japan should pursue over the next 10 years. The basic concept of the recommendation was for science and technology to contribute to the international society and humanity as a whole, and achieve the following goals. • Coexistence of Humans in Harmony with the Earth • Expansion of Intellectual Stock • Construction of a Charming Society Where People Can Live with Peace of Mind Based on this report, the General Guidelines for Science and Technology Policy was adopted in April 1992.

(Table 3-2-1)

Title	Date	Outline
Recommendation for Inquiry No. 19 "Basic plans for Research and Development on Soft Science and Technology"	December 2, 1992	This report addresses research and development related to soft science and technology that contributes to the support of intellectual activities, improvement in the comfort of the living environment, and balance with people and society. It indicates the basic thinking of Japan in its promotion of this research and development, the important research and development issues that the Government should address, and policies for the promotion of each.
Recommendation for Request No. 20 "Comprehensive Basic Policy for Getting Scientific and Technological Personnel"	December 12, 1994	This report calls for all people to have a deep concern for science and technology, defines human resources in the fields of science and technology as all persons who are involved directly in R&D and industrial activities, such as researchers and technicians, and indicates the basic philosophy regarding how the government can secure these human resources. Since solving this problem will require persistent efforts and close cooperation from many persons involved, items requested of people outside of the government towords the securing of human resources are also detailed.
Recommendation for Request No. 21 "Basic Plans for R&D on Advanced Fundamental Science and Technology"	December 12, 1994	Advanced fundamental science and technologies have two aspects: 1) science and technology used as a tool for promoting research, and 2) science and technology, which is the basis for solving comprehensively complex problems through fusion of multiple fields of science and technology. This report indicates important R&D subjects to be given special emphasis over the next 10 years or so and the associated goals.

3.2.1 The General Basic Policy

Recommendation Pursuant to Inquiry No. 18 "Comprehensive and Basic Science and Technology Policy toward the New Century"; (referred to as Recommendation 18 below). (submitted on January 24, 1992)

Major changes both at home and abroad are occurring in science and technology. In the international areas, there is progress in the easing of East-West tensions. There is movement among the members of the European Community (EC) towards unification, and we are confronted with the problems to solve in order for mankind to survive and prosper, such as environmental issues. Domestically, these changes include rising expectations for improvements in the standard of living, and the rising demand for fulfillment of a healthy, safe and comfortable life.

Therefore, on June 22, 1990, the Prime Minister presented Inquiry No. 18 *"Comprehensive and Basic Science and Technology Policy Toward the New Century"* to the CST to decide upon basic general policies on science and technology for the next 10 years with a view towards the future. In response to the inquiry, the CST deliberated for one and a half years and submitted a recommendation to the Prime Minister on January, 1992.

The basic concept of the recommendation was for science and technology to contribute to international society and humanity as a whole, and achieve the following goals.

- Coexistence of humans in Harmony with the Earth
- Expansion of Intellectual Stock
- Construction of a Charming Society Where People Can Live with Peace of Mind

It was suggested that active and general policies on science and technology should be developed.

3.2.2 Basic Plan for Important Areas of Research and Development

3.2.2.1 Views Concerning Basic Plans for Research and Development on Energy

(submitted on June 21, 1991)

Major changes are taking place in the energy situation as can be seen by the increase in global environmental problems and other issues, and therefore, the CST has put together a new proposal on a basic plan for energy R&D which was reported in June, 1991. In response, a new basic plan was decided in July, 1991.

In the basic plan, the following issues were defined for energy R&D programs.

(1) Secure a stable supply of energy
(2) Construct an energy saving society
(3) Respond to global environmental problems
(4) Contribute to international society

On the basis of these requests, the following items were arranged as important R&D topics which the government should be central in promoting for the next 10 years.

- Diversification of energy sources
- Increase in efficient use of energy
- Reduction of burden on the environment
- International response
- Basic and fundamental technology

In addition, amendments to the Basic Plan were carried out based on changes in the global energy situation in recent years, including the outlook for increasing worldwide demands on energy and the intensified debate regarding global environmental issues.

3.2.2.2 Recommendation for Inquiry No. 19 "Basic Plan for R&D on Soft Science and Technology"

(submitted on December 2, 1992)

Science and technology is facing a period of major change in this complex, advanced society where support for intelligent action is desired; a place where we have broken the shackles of a possession-oriented mass production/mass consumption society and come to desire a high-quality, enriched and unhurried lifestyle. Under these circumstances, in January 1991, the Prime Minister considered the need to promote planned R&D of soft science and technology in wide-ranging areas and made an inquiry to the CST concerning basic R&D plans for soft science and technology. The CST received this request and set up a new Subcommittee for Soft Science and Technology made up of well-informed individuals from a wide range of fields, from natural sciences to cultural and social sciences. This Subcommittee carried out investigations and deliberated on this request in the long-ranging viewpoint for approximately 10 years. On December 2, 1992, after 2 years of investigation, the Subcommittee submitted a report on their findings concerning this request. Furthermore, based upon this report, a Basic Plan for R&D on Soft Science and Technology has been decided in January 1993 (decided upon by the Prime Minister).

In this report, it is stated that R&D developments in soft science and technology often require knowledge and procedures of natural sciences and cultural and social sciences mutually. Furthermore, as this is a relatively new area of science and technology, it is stated that R&D developments must be carried out placing continual importance on exterior, environmental elements that promote research, these being; the establishment of scientific and R&D fundamentals, planned advancement in R&D, consolidated research exchanges between the natural and cultural and social science fields, ensuring communication between science and technology and society, and the advancement of international exchanges.

3.2.2.3 Recommendation for Request No. 20 "Comprehensive Basic Policy for Getting Scientific and Technological Personnel"

(December 12, 1994)

The efforts of researchers, technicians and other personnel in scientific and technological fields are very important for Japan's development and prosperity in today's environment of high level scientific and technological advances.

The stepping up of science and technology will be indispensable to finding the solutions to various global problems, meeting the needs of a diversified population, and maintaining an international level of competitiveness. The reinforcement and securement of scientific and technical personnel is now more important than ever before.

However, due to troubling factors such as the decreasing birth rate, aging of the population and the decreasing interest in science and technology among young people, the outlook for the future is not one of optimism.

Under such conditions, the Prime Minister submitted to the CST in December, 1992, Inquiry No. 20, Comprehensive Basic Policy for Getting Scientific and Technological Personnel. The CST accordingly formed new subcommittee on human resources in science and technology fields, and has conducted discussions and investigations into concrete policies for solving the various problems associated with the securement of human resources.

At the June 1994 plenary meeting of the CST, the interium report was executed and opinions of it were drawing from all fields. On December 12, 1994, a response was sent to the Prime Minister, who on December 27 determined the Basic Policy for Securing Human Resources in the Fields of Science and Technology based on this response.

This policy calls for all people to have a deep concern for science and technology, defines human resources in the fields of science and technology as all persons who are involved directly in R&D and industrial activities, such as researchers and technicians, and indicates the basic philosophy regarding how the government can secure these human resources.

Since solving this problem will require persistent efforts and close cooperation from many persons involved, items requested of people outside of the government towards the securing of human resources are also detailed. Based on the guiding principle that a diverse and flexible environment which respects individual personalities and encourages creativity must be established, policies are aimed at 1) creating a social environment in which there is intimacy with science and technology, 2) the maintenance of an R&D environment which encourages creativity, and 3) the encouragement of diverse human resources to participate in science and technology activities.

3.2.2.4 Recommendation for Request No. 21 "Basic Plans for Research and Development on Advanced Fundamental Science and Technology"

(December 12, 1994)

State-of-the art procedures used in common in different scientific and technical fields, or leading basic foundation science and technology, assists developments in all fields, assists in the joining of different fields, opens new fields where it can be applied, and offers a new path to solve problems that could not be dealt with effectively by the traditional methods of the past.

In order to plan for increased promotion of leading basic science and technology from here onward, continuous utilization of comprehensive knowledge from a wide range of fields, in addition to planned R&D activity in these fields, must be carried out. As such, in June 1993, the Prime Minister submitted to the CST an request on the Basic Plan for Research and Development in Leading Basic Science and Technology. The CST established a panel on advanced fundamental science and technology, which performed studies and deliberations. On December 12, 1994, a reply was sent to the Prime Minister, who on December 27 determined "the Basic Plan for Research and Development on Advanced Fundamental Science and Technology" based on this reply.

The Basic Plan for Research and Development on Advanced Fundamental Science and Technology indicates policies for promoting science and technology in fields, where increase the complexity of problems which science and technology is expected to solve, and the importance of advanced tools and techniques to support R&D activities.

Advanced fundamental sciences and technologies is expected to involve advanced technique used commonly in different scientific and technical fields, and bring breakthroughs in science and technology. They have two aspects: 1) laboratory technologies, which used as a tool for promoting research, and 2) multi-disciplinary technologies, which is the basis for solving comprehensively complex problems through fusion of multiple fields of science and technology. The Basic Plan indicates important R&D subjects to be given special emphasis over the next 10 years or so and the associated goals. In the field of laboratory technology, 30 subjects with 104 themes in multi-disciplinary technology, 13 subjects with 73 themes are mentioned.

3.2.2.5 Inquiry No. 22: Basic Guidelines for Boosting Regional Scientific and Technological Activities

(June 20, 1994)

Regional scientific and technological activities become the driving force for the energization of a region. In addition to contributing to the formation of a diversified country, such activities also help improve the quality of life of the residents through solving the various problems faced by the region. Furthermore, the boosting of unique regional scientific and technological activities will become increasingly important for such purposes as advancing new technological innovations, raising the people's level of interest in science and technology, encouraging increasing understanding and participation, increasing the number of young people who aspire to enter scientific and technological fields, and indeed, the boosting of scientific and technological activities in Japan on the whole.

In order to further step up the boosting of regional scientific and technological activities, the ideal method must be discussed, the necessary environmental maintenance must be planned, and active assistance must be given to regions which are making independent and original efforts. Accordingly, the Prime Minister submitted the inquiry on Basic Guidelines for Boosting Regional Scientific and Technological Activities (June 1994) to the CST. Since receiving this inquiry, the CST has newly established a subcommittee on the promotion of regional science and technology.

3.2.2.6 Proposal for Fundamental Planning of R&D Concerning Disaster Prevention

(November 24, 1993)

The current fundamental planning of R&D concerning disaster prevention was decided upon in 1981 by the Prime Minister, and since then, R&D for disaster prevention in Japan has been carried out based upon this policy. All R&D for disaster prevention carried out based upon the original plan in the more than 10 years since this decision was made. However, the environment surrounding these R&D activities is undergoing major changes, such as changes in the composition of society and increased demand for international contribution and cooperation from Japan. In regard to these changes, the CST submitted a new proposal for Fundamental Planning of R&D Concerning Disaster Prevention in November 1993. As a result, the new Basic Plan was determined by the Prime Minister in December 1993. The Plan is based on variations in the social situation, and includes sections such as Variations in Social Structure; The Growing Need for International and Global Perspectives; The Growing Need for Educating Awareness of Disaster Prevention; The Growing Need for Compatibility between the Environment and Disaster Prevention; and The Progress of New Technologies. The contents of the research and development which Japan should be undertaking for the next ten years was clarified in the sections, Understanding and Predicting Natural Phenomena; Technology for Preventing Meteorological Disasters; Technology for Preventing Terrestrial Disasters; and Science and Technology for Comprehensive Disaster Prevention.

3.2.3 Comprehensive Coordination of Policies for Science and Technology Promotion

3.2.3.1 The Special Coordination Funds for Promoting Science and Technology (SCF)

The SCF were first established in FY1981 to facilitate the comprehensive promotion of science and technology as a funded system; they are expended in accordance with the guidelines decided by the CST. Administration of the SCF is based on a policy document entitled *The Guiding Principals for the Special Coordination Funds for Promoting Science and Technology* which was adopted by the CST in March 1981 and finally revised in January 1992. More specifically, the SCF are expended in accordance with the annual guideline of the CST Policy Committee.

In FY 1994, new investigations and research were launched regarding the development, operation and utilization of the Inter-Ministry Research Information Network which link with domestic and foreign research organizations and existing networks. Investigation and research regarding the creation of databases of fundamental and basic data were also launched.

3.2.3.2 Guideline on the Priority for Promoting Science and Technology

The Committee on Policy Matters decides annually the Guideline on the priority for promoting science and technology along the line with the General Guideline for Science and Technology Policy.

In June 1994, the following items were selected as priority items for promotion in the *Basic Guidelines for Implementing Priority Programs for the Promotion of Science and Technology for FY1995*.

- Increased funds for basic research at universities and national research institutes.
- Renewal of facilities to support advanced research and update superannuated facilities and equipment.
- Strengthening of the R&D bases such as maintenance of the research information distribution base, improvement of the research supporting functions, etc.
- Improvement of the research environment.
- Enrichment of human resources in science and technology activities.
- Strengthening international science and technology activities.

3.2.3.3 Basic Investigations for Planning Science and Technology Policies

The Sub-committee on Research Projects under the CST Committee on Policy Matters undertakes background investigations and analyses in areas deemed essential to the formulation of policies for comprehensive and effective R&D promotion. Investigations are financed with appropriations from the SCF.

In FY1994, investigations were conducted on the following:

- Collection and analysis of basic data necessary for discussions on policies for effective promotion of R&D
- Search of policies for promotion of major R&D

In addition, The Science and Technology Forum has being held every year as a part of the basic investigations, with the theme for 14th forum being "The Partnership of the Natural Sciences and the Humanities and Social Sciences: Part II—Beyond the Conflict of Sense and Sensibility—" The 14th forum on science and technology was held in March 1995.

3.2.3.4 Investigation Concerning the Research Information Network

The CST's Ad-Hoc Committee on the Research Information Network carried out discussions on how Japan's research information network should be maintained based on the situation of the research information network inside and outside of Japan, researcher needs and other matters. In June 1994, the committee put forth On Immediate Promotional Ways Relating to Research Information Network. The committee is now continuing its discussions regarding the future of the research information network, including policies to build on information sources which circulate through the network.

3.2.3.5 Follow-up Activities for CST Recommendations

Follow-up activities for CST recommendations are conducted in the Committee on Policy Matters to realize the policies recommended and to coordinate the science and technology policies.

The Report on Measures Taken for the Promotion of Science and Technology has been annually compiled and published, summing up government policies in relation to Request No. 18.

3.2.3.6 International Activities

The rapid changes in the international situation around Japan have resulted in the recognition that the necessity to contribute to the international society in the field of science and technology is increasingly important.

High level policy issues are increasing rapidly, such as international cooperation in large-scale and long-term R&D, and global environmental problems.

Therefore, the CST is expected to make its own decision to develop international activities more actively.

3.2.3.6.1 The Carnegie Group Meeting (Government Summit Meeting of Science and Technology Advisors)

The members of the meeting consist of advisors on science and technology to the leaders of the summit member countries, the EC and the former Soviet Union or Cabinet Ministers in charge of science and technology, with nine members all together. By the suggestion of Dr. Bromley, the then Presidential Advisor on U.S. Science and Technology, the purpose of the meeting was to exchange opinions on various problems concerning science and technology, report the results to the leaders of each country and reflect them at the summit talks.

As the latest one, the 9th meeting was held in Warrenton, U.S.A. in May 1995.

3.2.3.6.2 The Meeting of Presidents of Research Councils of G7

The meeting proposed by Dr. Heinz Maier-Leabnitz, the then president of German Research Foundation, which conducts open debate concerning various science and technology related issues with representatives from the Research Councils of the summit countries attending. The conference has been held annually for 14 years, and Japan has participated since the 6th meeting. Recently, the conference was held in Elkridge, U.S.A. in May 1995. Options about sciences and technology issues in those countries were exchanged in the meeting.

3.2.3.6.3 Ad-hoc Committee on International Affairs, Committee on Policy Matters, Council for Science and Technology

The Committee on Policy Matters structured a new Ad-hoc Committee on International Affairs, which began discussions in January 1995, in order to consider a new international progression for Japan's science and technology policy based on recent changes in the international situation, including the end of the Cold War, economic fluctuations, such as the economic slackening of leading nations and the economic growth of Asian nations, and the growing severity of global issues, such as the condition of the earth's environment.

3.2.3.6.4 Others

Other than these meetings, the CST organizes the International Invitation Program from FY1990. Important persons abroad involved in science and technology policy are invited to exchange opinions with members of the Committee on Policy Matters of the CST.

3.2.3.7 Regional Activities

The CST, in cooperation with the regions, has been conducting an annual regional science and technology policy forum since FY1992, where various scientific and technical problems from the administrative sections of Japan are debated. Researchers connected with wide regional science and technology policy, administrative officers, etc., participate in this forum.

The conference was held recently in October 1994 in Iwate Prefecture, where topics such as the development of creative regional R&D and its industrialization were debated.

In addition, the "Meeting on Regional Science and Technology Policy" held in FY1991 and FY1992 with members of the Committee on Policy Matters of the CST and the Chairmen of Regional Councils on Science and Technology. The meeting is to strengthen collaboration between the CST and Prefectural Councils on Science and Technology and to contribute to planning regional science and technology policies.

3.3 Administrative Structures of Science and Technology and Budget

3.3.1 Administrative Structure

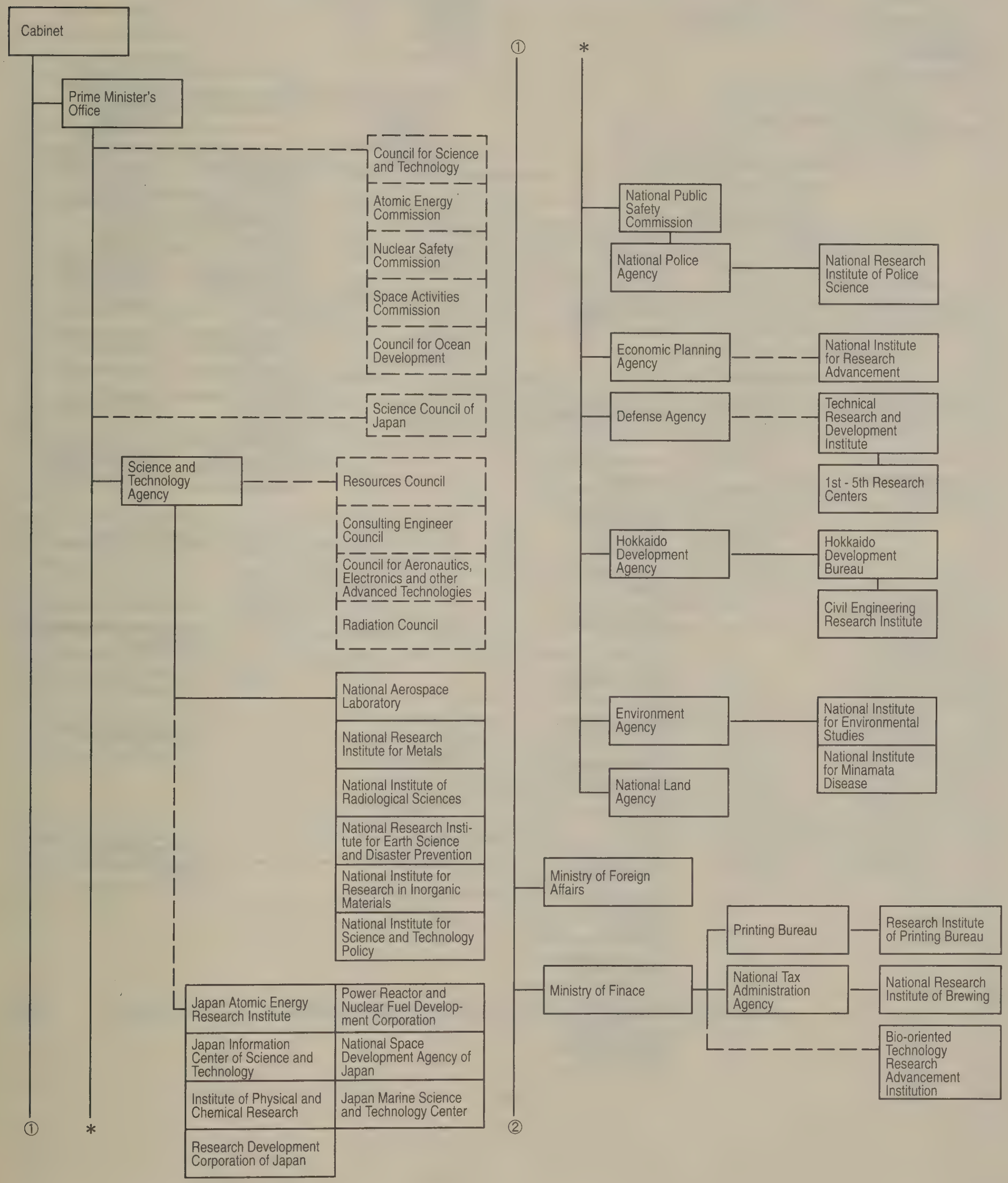
In principle, each government ministry or agency has Jurisdiction over the promotion of its own science and technology programs. Research is carried out at relevant national research institutes, public research corporations and national universities, including inter-university research institutes.

For example, the Ministry of Education administers academic research programs; the Ministry of Health and Welfare conducts research with the goal of improving health medical care and social welfare; the Ministry of Agriculture, Forestry and Fisheries carries on research for the nation's agriculture, forestry and fisheries; the Ministry of International Trade and Industry carries on mining and industry research; the Ministry of Transport has jurisdiction over transport-related research programs; and the Ministry of Posts and Telecommunications oversees telecommunications research (Figure 3-3-1).

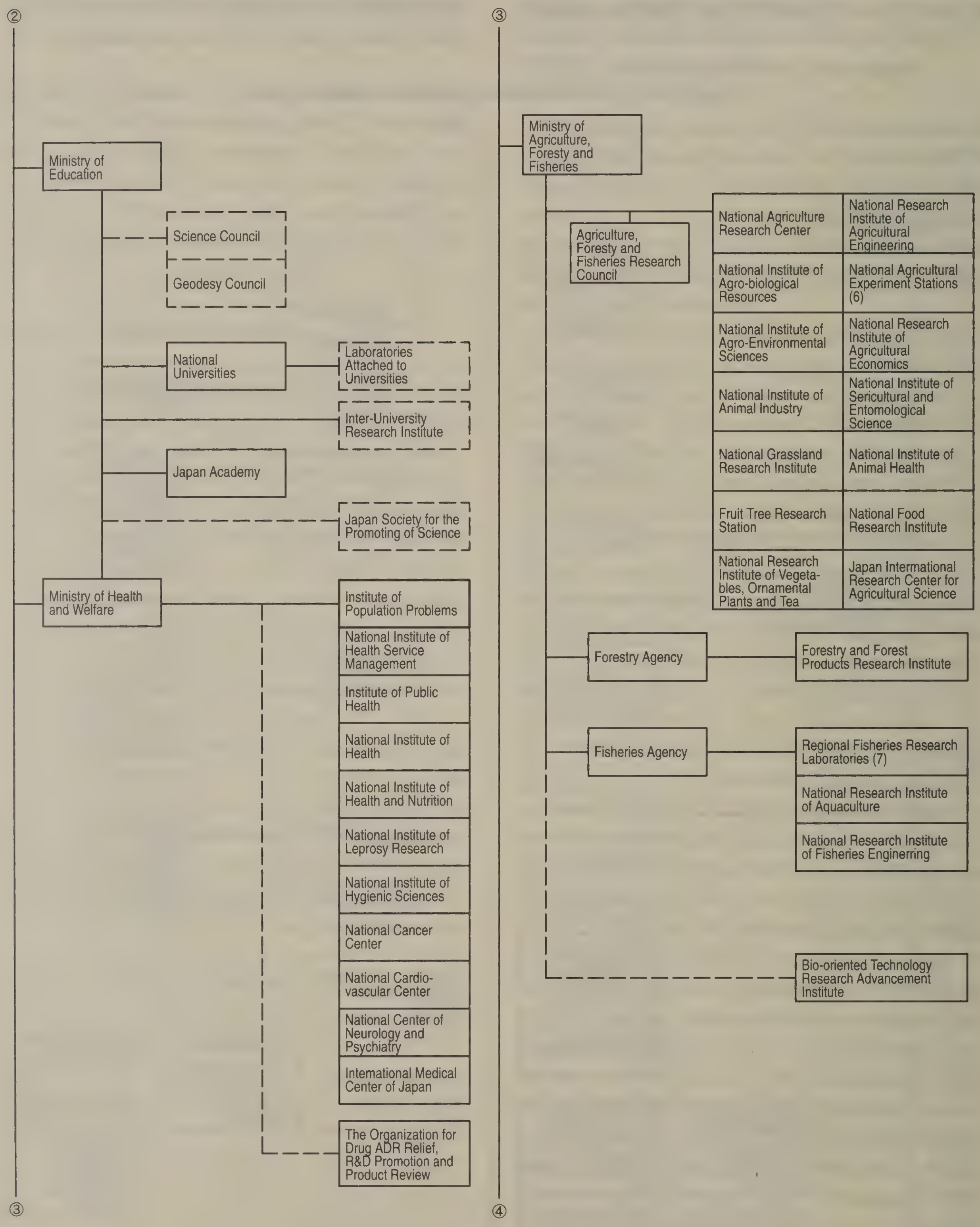
Some institutions, such as the Japan Key Technology Center, the Bio-oriented Technology Research Advancement Institution, the Organization for Drug ADR Relief R&D Promotion and Product Review and the New Energy and Industrial Technology Development Organization, support R&D activities in the private sector.

The Science and Technology Agency maintains the comprehensibility of the country as whole, and conducts planning, drafting, and promotion of fundamental policies related to science and technology in order to promote efficient and effective use of science and technology. The Agency also coordinates budget estimates for laboratory research facilities and performs clerical work related to the Special Coordination Funds for Promoting Science and Technology(SCF). Through such functions, the Agency oversees the management of the science and technology functions of relevant administrative agencies, as well as general promotion science and technology related administration, such as R&D in leading, critical science and technology fields and the strengthening and enrichment of creative and basic research (The Agency has no jurisdiction over science and technology research carried out at universities and colleges, nor for research programs related solely with the humanities).

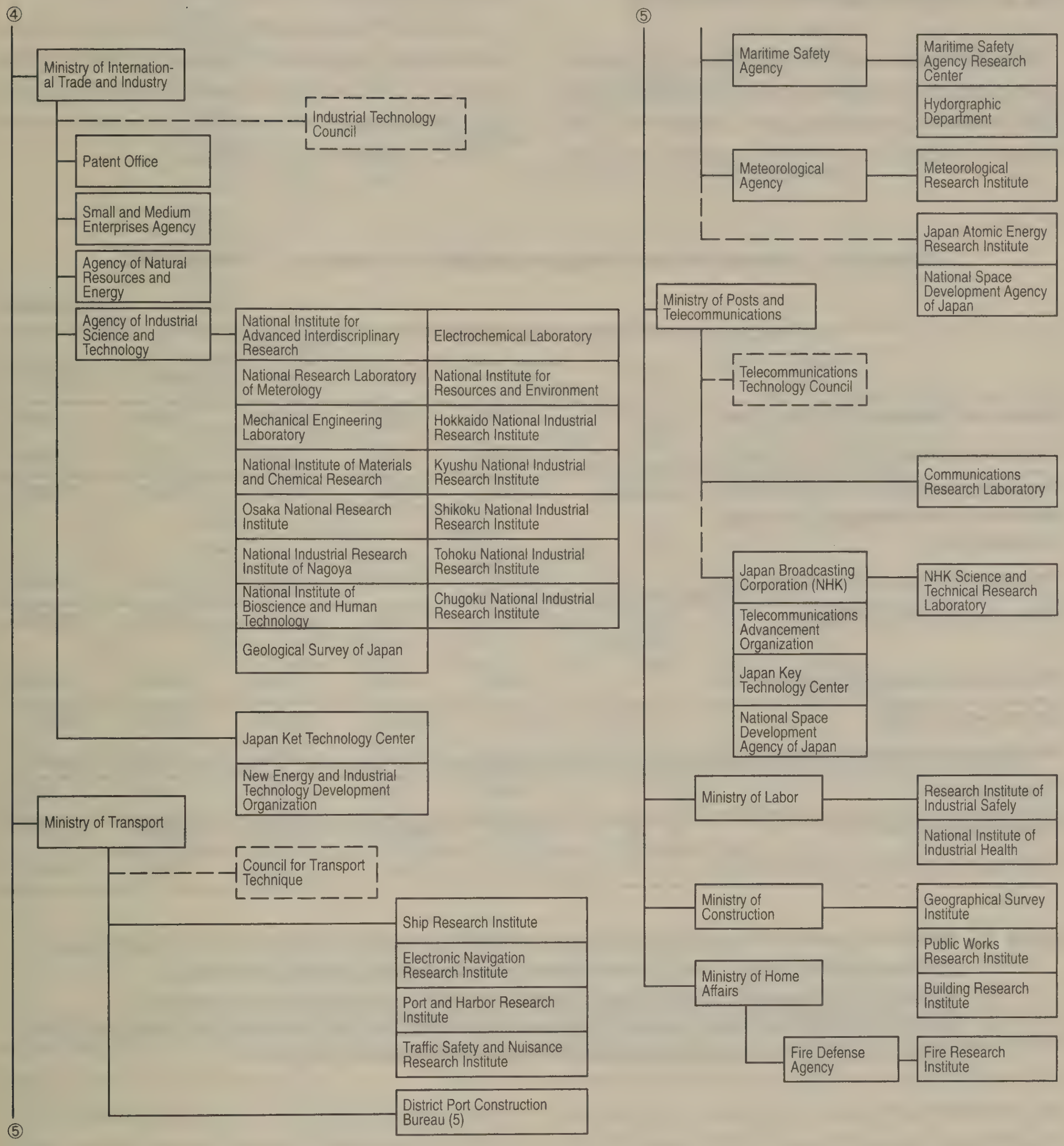
Figure 3-3-1 Administrative structure (March 1995)


Cabinet
Prime Minister's Office
Council for Science and Technology
Atomic Energy Commission
Nuclear Safety Commission
Space Activities Commission
Council for Ocean Development
Science Council of Japan
Science and Technology Agency
Resources Council
Consulting Engineer Council
Council for Aeronautics, Electronics and other Advanced Technologies
Radiation Council
National Aerospace Laboratory
National Research Institute for Metals
National Institute of Radiological Sciences
National Research Institute for Earth Science and Disaster Prevention
National Institute for Research in Inorganic Materials
National Institute for Science and Technology Policy
Japan Atomic Energy Research Institute
Power Reactor and Nuclear Fuel Development Corporation
Japan Information Center of Science and Technology
National Space Development Agency of Japan
Institute of Physical and Chemical Research
Japan Marine Science and Technology Center
Research Development Corporation of Japan
①
*
①
*
National Public Safety Commission
National Police Agency
National Research Institute of Police Science
Economic Planning Agency
National Institute for Research Advancement
Defense Agency
Technical Research and Development Institute
1st - 5th Research Centers
Hokkaido Development Agency
Hokkaido Development Bureau
Civil Engineering Research Institute
Environment Agency
National Institute for Environmental Studies
National Institute for Minamata Disease
National Land Agency
Ministry of Foreign Affairs
Ministry of Finace
Printing Bureau
Research Institute of Printing Bureau
National Tax Administration Agency
National Research Institute of Brewing
Bio-oriented Technology Research Advancement Institution
②

(Figure 3-3-1 Administrative structure (March 1995)


②
Ministry of Education
Science Council
Geodesy Council
National Universities
Laboratories Attached to Universities
Inter-University Research Institute
Japan Academy
Japan Society for the Promoting of Science
Ministry of Health and Welfare
Institute of Population Problems
National Institute of Health Service Management
Institute of Public Health
National Institute of Health
National Institute of Health and Nutrition
National Institute of Leprosy Research
National Institute of Hygienic Sciences
National Cancer Center
National Cardio-vascular Center
National Center of Neurology and Psychiatry
International Medical Center of Japan
The Organization for Drug ADR Relief, R&D Promotion and Product Review
③
③
Ministry of Agriculture, Foresty and Fisheries
Agriculture, Foresty and Fisheries Research Council
National Agriculture Research Center
National Research Institute of Agricultural Engineering
National Institute of Agro-biological Resources
National Agricultural Experiment Stations (6)
National Institute of Agro-Environmental Sciences
National Research Institute of Agricultural Economics
National Institute of Animal Industry
National Institute of Sericultural and Entomological Science
National Grassland Research Institute
National Institute of Animal Health
Fruit Tree Research Station
National Food Research Institute
National Research Institute of Vegeta-bles, Ornamental Plants and Tea
Japan International Research Center for Agricultural Science
Forestry Agency
Forestry and Forest Products Research Institute
Fisheries Agency
Regional Fisheries Research Laboratories (7)
National Research Institute of Aquaculture
National Research Institute of Fisheries Enginerring
Bio-oriented Technology Research Advancement Institute
④

(Figure 3-3-1 Administrative structure (March 1995)


④
Ministry of Internation-al Trade and Industry
Industrial Technology Council
Patent Office
Small and Medium Enterprises Agency
Agency of Natural Resources and Energy
Agency of Industrial Science and Technology
National Institute for Advanced Interdisciplinary Research
Electrochemical Laboratory
National Research Laboratory of Meterology
National Institute for Resources and Environment
Mechanical Engineering Laboratory
Hokkaido National Industrial Research Institute
National Institute of Materials and Chemical Research
Kyushu National Industrial Research Institute
Osaka National Research Institute
Shikoku National Industrial Research Institute
National Industrial Research Institute of Nagoya
Tohoku National Industrial Research Institute
National Institute of Bioscience and Human Technology
Chugoku National Industrial Research Institute
Geological Survey of Japan
Japan Ket Technology Center
New Energy and Industrial Technology Development Organization
Ministry of Transport
Council for Transport Technique
Ship Research Institute
Electronic Navigation Research Institute
Port and Harbor Research Institute
Traffic Safety and Nuisance Research Institute
District Port Construction Bureau (5)
⑤
⑤
Maritime Safety Agency
Maritime Safety Agency Research Center
Hydorgraphic Department
Meteorological Agency
Meteorological Research Institute
Japan Atomic Energy Research Institute
National Space Development Agency of Japan
Ministry of Posts and Telecommunications
Telecommunications Technology Council
Communications Research Laboratory
Japan Broadcasting Corporation (NHK)
NHK Science and Technical Research Laboratory
Telecommunications Advancement Organization
Japan Key Technology Center
National Space Development Agency of Japan
Ministry of Labor
Research Institute of Industrial Safely
National Institute of Industrial Health
Ministry of Construction
Geographical Survey Institute
Public Works Research Institute
Building Research Institute
Ministry of Home Affairs
Fire Defense Agency
Fire Research Institute

Note: Laboratories or institutes related only to the humanities are not included.

3.3.2 Expenditures Allocations

In Fy1995, the national science and technology expenditures totaled 2.4908 trillion yen, up 5.6% from the preceding year. Compared to the previous year, the FY1995 General Account Budget fell 2.9% and the General Budget Expenditure increased by 3.1% (Table 3-3-2).

In FY1995, expenditures for the science and technology promotion fund were 684.4 billion yen, up 7.5%, and other research-related expenditures primarily at national universities were 1,806.5 billion yen, up 4.9%.

Table 3-3-2 Science and technology expenditure allocations — 1991 to 1995

(¥100 million)

Item		Fiscal Year				
		1991	1992	1993	1994	1995
Science and Technology Promotion Fund	(A)	5,074	5,478	5,944	6,364	6,844
Percentage increase over the previous year	%	106.7	108.0	108.5	107.1	107.5
Research appropriations other than those earmarked in the Science and Technology Promotion Fund	(B)	15,153	15,868	16,718	17,221	18,065
Percentage increase over the previous year	%	104.8	104.7	105.4	103.0	104.9
Science and Technology Budget	(C)=(A)+(B)	20,226	21,347	22,663	23,585	24,908
Percentage increase over the previous year	%	105.3	105.5	106.2	104.1	105.6
General Account Budget	(D)	703,474	722,180	723,548	730,817	709,871
Percentage increase over the previous year	%	106.2	102.7	100.2	101.0	97.1
(C)÷(D)×100	%	2.88	2.96	3.13	3.23	3.51
General Budget Expenditure	(E)	370,365	386,988	399,168	408,548	421,417
Percentage increase over the previous year	%	104.7	104.5	103.1	102.3	103.1

Notes: 1. Amounts shown for research appropriations other than those earmarked in the Science and Technology Promotion Fund (B) are Science and Technology Agency estimates.
2. All amounts represent initial budgets or appropriations for the respective fiscal year.
3. Since amounts have been rounded, the sum of the amounts and percentages for each column, and the totals and percentages shown above do not necessarily agree.

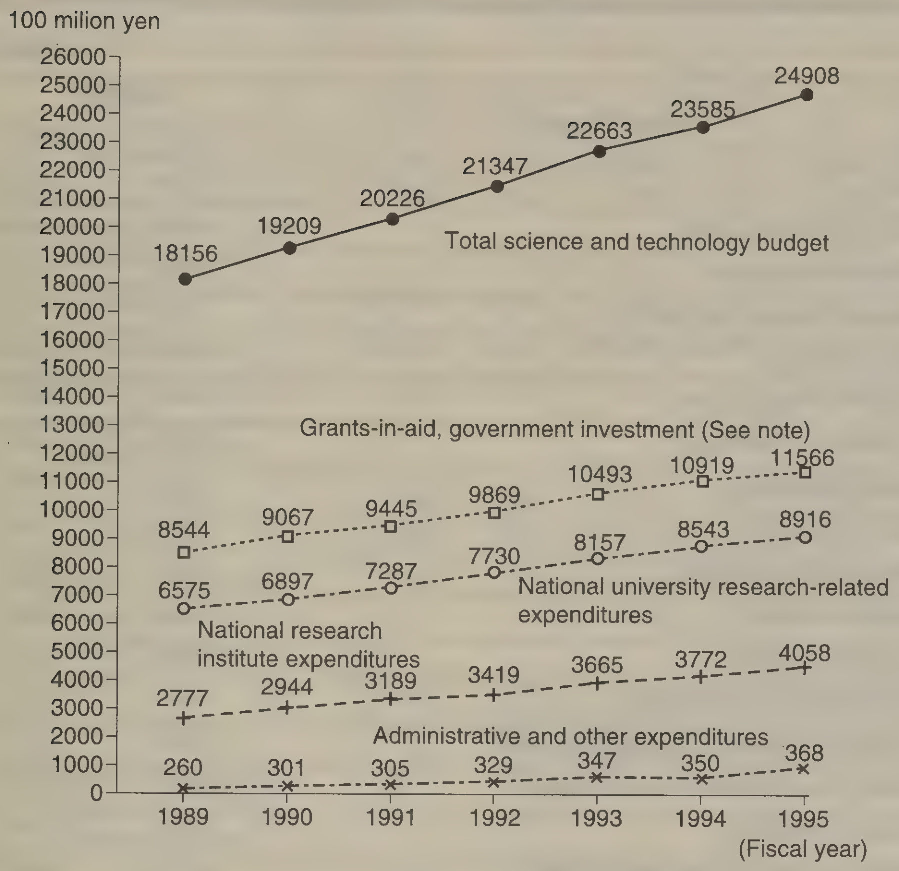


Figure 3-3-3 Changes in research budgets earmarked in the Science and Technology Budget

Note: In addition to grants-in-aid, the above amount marked with an asterisk includes commissioned project costs, investments (financing) and share of the expenses.

Figure 3-3-3 shows trends in research allocations from the science and technology expenditures over the last seven years.

As shown in Figure 3-3-3, FY1995, expenditures for the national research institutes, including costs of research, personnel and facilities, totaled 405.8 billion yen, up 7.6%. Grants-in-aid, commissioned project costs, investments and shared costs were 1,156.6 billion yen, a 5.9% increase over the preceding year and accounted for 46.4% of the total science and technology budget. This expenditure consists of government support for large R&D projects, grants-in-aid and commissioned project costs to public research corporations and the private sector. Table 3-3-4 provides the breakdown of the science and technology expenditures for FY1994 and 1995 by government ministries or agencies. Table 3-3-5 compares the overall trend in allocations for science and technology in the expenditures of five selected countries. However, since fiscal accounting procedures differ from country to country, it is difficult to make direct comparisons, particularly regarding the actual amounts of money allocated.

Table 3-3-4 Science and technology expenditure breakdown by ministries and agencies

(¥million)

Ministry or agency	Fiscal Year	
	1994	1995
Diet	549	560
Science Council of Japan	1,201	1,123
National Police Agency	1,358	1,435
Hokkaido Development Agency	164	164
Defense Agency	140,788	154,499
Economic Planning Agency	986	991
Science and Technology*	605,238	646,120
Environment Agency	13,427	14,733
Ministry of Justice	1,353	1,433
Ministry of Foreign Affairs	9,467	10,271
Ministry of Finance*	2,652	2,526
Ministry of Education*	1,100,356	1,157,384
Ministry of Health and Welfare*	69,891	70,813
Ministry of Agriculture, Forestry and Fisheries*	82,660	85,418
Ministry of International Trade and Industry*	283,653	297,058
Ministry of Transport*	22,932	21,862
Ministry of Posts and Telecommunications*	34,966	36,916
Ministry of Labor*	4,085	4,529
Ministry of Construction	8,055	8,276
Ministry of Home affairs	692	727
Total	2,358,474	2,490,838

Notes:
1. All amounts represent initial expenditure or appropriations for the respective fiscal year.
2. Since amounts have been rounded off, the sum of the amounts for each column, and the totals shown above do not necessarily agree.
3. The amounts for the ministries and agency marked with asterisks include the Science and Technology Expenditure appropriations from Special Accounts.
4. Some amounts include appropriations for humanities.

Table 3-3-5 Science and technology expenditures of selected countries

Country		Fiscal Year						
		1989	1990	1991	1992	1993	1994	1995
Japan	100 million yen	18,156	19,209	20,226	21,347	22,663	23,585	24,908
	Percentage of the Science and Technology Budget in the General Account Budget (%)	3.01	2.90	2.88	2.96	3.13	3.23	3.51
United States	US$ million	60,760	63,810	62,183	64,728	68,378	66,453	68,864
	100 million yen	83,849	92,397	83,761	82,010	76,036	67,915	—
	Percentage of the Science and Technology Allocation in the National Budget (%)	5.3	5.1	4.7	4.7	4.9	4.5	4.5
Germany	DM. million	14,036	15,149	16,806	17,227	17,245	16,747	—
	100 million yen	10,300	13,575	13,643	13,971	11,599	10,547	—
	Percentage of the Science and Technology Allocation in the National Budget (%)	4.8	4.0	4.2	4.0	3.8	3.5	—
France	Fr. million	75,008	78,054	77,773	79,900	80,586	79,768	—
	100 million yen	16,217	20,755	18,572	19,112	15,827	14,685	—
	Percentage of the Science and Technology Allocation in the National Budget (%)	6.2	6.4	6.1	6.0	5.9	5.6	—
United Kingdom	£. million	4,638	4,835	5,048	5,199	5,449	5,322	—
	100 million yen	10,491	12,493	12,034	11,624	9,094	8,328	—
	Percentage of the Science and Technology Allocation in the National Budget (%)	3.9	3.7	3.5	3.3	3.2	3.1	—

Notes: 1. The accounting procedures for national expenditures and for science and technology allocations from national expenditures vary from country to country.

2. The amounts for Germany represent the federal budget and do not include the majority of expenditures for research at universities which are shouldered by state governments. The budget till 1990 includes only that of former West Germany. The budgets for 1993 and 1994 are estimates.

Sources: Japan — The Budget Book.
United States — Budget Buselines, Historical Data, and Alternatives for the Future 1993.
Germany — Bundesbericht Forschung 1993, Statistishe Informationen, Finanzbericht.
France — Projet de loi de Finances – Etat de la Recherche et du Développement Technologique, Les Notes Bleues.
United Kingdom — Forward Look 1994.

3.4 Promotion of Research Activities

3.4.1 Promotion of Important Areas of Research and Development

3.4.1.1 Basic and Leading Science and Technology Fields

3.4.1.1.1 Materials Science and Technology

Substance/Material Series of Science and Technology has not only been making contributions of new scientific knowledge by clarifying phenomena/functions that occur at the atomic or molecular level or in ultimate environments such as ferromagnetic fields and ultra-high-vacuum or ultra-high pressure. It has also had an extremely large influence on the economic world in the past through the discovery of new materials. As can be seen in the example of new superconductors, the appearance of new materials cultivates new technology and brings qualitative changes to even related technology, which has had a great impact on society, and of course industry as well.

The discovery of new materials has always strongly influenced societies and their economies. Such materials open the door to new fields in technology that substantially alter existing ones, precipitating changes in the manufacturing sector and in society as a whole. A recent example of such a force for change is the discovery of new superconductive materials.

The exploration of many potential R&D fields in advanced disciplines, such as information/electronics science and technology and life sciences, awaits the development of new advanced materials. The key to advancing this development is R&D in materials science and technology — the common and basic technology that supports the innovative research that lies at the basis of a scientific and technological nation.

Today the need for advanced materials is especially acute in big R&D projects related to supercomputer development, fusion technologies, and space and ocean research and development. The research, development and production of new materials are treated as an immediate priority in the nation's science and technology programs.

3.4.1.1.1.1 Comprehensive Promotion of Materials Science and Technology

Accordingly, the government is currently implementing policies for further advances in many fields of materials science and technology. This is in keeping with the CST's recommendation on priority and also is in conformance with recommendations from the Council for Aeronautics, Electronics and Other Advanced Technologies.

In May 1986 the Prime Minister presented Inquiry No. 14, *Basic Plan for R&D in the Field of Materials Science and Technology,* to the CST for deliberation. The CST began an investigation of R&D objectives and guidelines, submitting its recommendation to the Prime Minister in August 1987. In response, the government announced *The Government Research and Development Plan on Substance/Material Series of Science and Technology* in October of the same year.

Furthermore, the conference studied Inquiry No. 18 *General Basic Policies on Science and Technology for the Next Century* (submitted in January, 1992) and indicated the necessity of developing substances and materials with high performance and new functions which go beyond existing limits.

Also, the Council for Aeronautics, Electronics and Other Advanced Technologies established general guidelines for the advancement of materials science and technology through recommendations made in the following reports:

- Recommendation pursuant to Inquiry No. 5, *The Concept of Ultimate Science for Advanced Materials and the Guidelines on R&D Promotion,* submitted in August 1980.
- Recommendation pursuant to Inquiry No. 7,

The Concept of New Advanced Materials' Design and the Guidelines on R&D Promotion, submitted in September 1984.

- Recommendation pursuant to Inquiry No. 9, *The Concept of Measurement Control Techniques for New Advanced Materials and the Guidlines on R&D Promotion,* submitted in March 1986.
- Recommendation pursuant to Inquiry No. 13, *The Concept of Intelligent Materials and the Guidelines on R&D Promotion,* submitted in November 1989.
- Recommendation pursuant to Inquiry No. 16, *The Concept of Analysis/Evalution Techniques for New Advanced Materials and the Guidelines on R&D Promotion,* submitted in November 1991.
- Recommendation pursuant to Inquiry No. 21, *Policy for the Promotion of Comprehensive Research and Development of Computation Science and Technology for the Understanding of Atomic and Molecular Phenomena and Functions,* submitted in February 1995.

3.4.1.1.1.2 Promotion of Materials R&D

Due to the demand for materials science and technology, government ministries and agencies are participating in R&D in this area.

The Science and Technology Agency is furthering common and basic research in materials science and technology through the work, for example, at the National Institute for Research in Inorganic Materials and the National Research Institute for Metals. Moreover the Agency supports research through the administration of the Special Coordination Funds for Promoting Science and Technology and a number of other programs, including Exploratory Research for Advanced Technology (ERATO), under the auspices of the Research Development Corporation of Japan (JRDC) and the International Frontier Research Program, under the auspices of the Institute of Physical and Chemical Research (RIKEN).

The Ministry of Education also is encouraging basic research in materials science and technology, as well as fostering creativity in the research environment utilizing Grants-in-aid for Scientific Research that allows scientists at national universities to pursue their own chosen avenues of study.

The Ministry of International Trade and Industry is conducting R&D Aimed at Creation and Processing Techniques for New Materials such as High-performance Materials for Severe Environments, according to the Industrial Science and Technology Frontier Program.

In addition, the Ministry of International Trade and Industry (MITI) promotes cutting-edge, basic R&D conducted by the international joint research teams through the International Joint Research Grant Project (NEDO grant) in order to improve the level of substance and materials science and technology internationally.

3.4.1.1.1.3 R&D in Superconductive Materials

The discovery of high, critical temperature oxide-based superconductors at the IBM Zurich Laboratories in Switzerland in 1986 captured the attention of the worldwide scientific community. In January 1988, the Science and Technology Agency's National Research Institute for Metals subsequently discovered the first of several bismuth-based superconducting compounds.

Although commercial applications of this family of materials are expected to dramatically affect the world's socioeconomic situation, the current reality is that superconductive materials are still far from being commercially useful. Basic and innovative R&D is needed in areas such as the theoretical description of high critical temperature superconducting behavior and in new materials research.

To this end, a number of government ministries and agencies are promoting R&D into superconductive materials in accordance with *The Basic Promotion for Research and Development on Superconductivity* compiled in November 1987 by the Ad-hoc Committee on Superconductivity which was set up under the CST's Policy Committee

The Science and Technology Agency set up *The Multi-core Research Project on Superconductivity* to promote the fundamental research required to realize the potential of new superconductive materials. This project takes a two-fold approach.

Firstly, it encourages maximum utilization of the R&D potential of research organizations such as the National Research Institute for Metals, the National Institute for Research in Inorganic Materials, the Japan Atomic Energy Research Institute, the Power Reactor and Nuclear Fuel Development Corporation, the National Space Development Agency of Japan, and the Institute of Physical and Chemical Research (RIKEN).

Secondly, it encourages joint research projects between Japanese and overseas scientists and fosters an environment that promotes the exchange of scientists and information.

The Ministry of Education is promoting basic research in superconductors utilizing Grant-in-aid for Scientific Research for innovative programs to researchers at the national universities.

The Ministry of International Trade and Industry also is promoting joint R&D projects on superconductive materials by promoting industrial-academic-government cooperation. The Ministry's work is mainly carried out as part of the Moonlight Project and the Research and Development Program on Basic Technologies for Future Industries, utilizing research institutes such as the Electrotechnical Laboratory and the National Chemical Laboratory for Industry as key institutes for cooperation. The Ministry also have commissioned the International Superconductivity Technology Center (ISTEC) to conduct R&D on superconductivity.

The Ministry of Posts and Telecommunications is pursuing R&D on superconductor technology for advanced telecommunications systems. This research is being carried out under the auspices of *Applications of Superconductors* as a part of the Frontier Research and Development for Next-generation Telecommunications Systems Program which is being promoted through industrial-academic-government cooperation centering on its Communications Research Laboratory.

Finally, the Ministry of Transport is supporting the R&D of a magnetic-levitation railway system using superconductors. This research is being funded by subsidies provided to the Railway Technical Research Institute (RTRI).

3.4.1.1.1.4 Promotion of International Cooperation in Materials Science and Technology

The government is supporting a number of bilateral and multilateral research projects and is encouraging the flow of information and interaction between researchers. Some of these projects are described below:

(1) Bilateral projects

- Research for High-Magnetic Field between the National Research Institute for Metals (Japan) and the Francis Bitter National Magnetic Laboratory (the National Science Foundation, the United States). This project was adopted in May 1990 under the Japan-U.S. Science and Technology Cooperation Agreement.

(2) Multilateral projects

- The Versailles Project on Advanced Materials and Standards (VAMAS)

Further, in 1990, Japan became the selected country for the International Electrotechnical Standard Commission's (IEC) recently established Technical Committee on Superconductivity (TC-90).

Table 3-4-1 summarizes the major R&D subjects in materials science and technology.

3.4.1.1.2 Information/electronics Science and Technology

3.4.1.1.2.1 Importance of Promotion

The role which information and electronics related science and technology performs is becoming increasingly important as we enter an advanced information society. Up to now, information- and- electronics-related science and technology has brought major innovations to economic and social activities through the growing sophistication and functionality of semiconductors and computers. It is predicted that information will increase qualitatively and quantitatively in the future, and higher functions in information processing such as intelligent processing and handling ambiguous data, efficient and accurate transmission of information with various input/output forms and R&D related to human interfaces with information processing and transmission are strongly desired.

With an understanding of this, reporting in March, 1989 in relation to Request No. 15, Basic Plan for Research and Development on Science and Technology Related to Information and Electronics, CST presented important R&D goals and promotion policy for research developments for the next 10 year

3.4.1.1.2.2 Important R&D Tasks

(1) Devices, etc.

Microelectronics R&D of high-speed logic devices and large-capacity memory devices are prerequisites for continued advancement in high-speed image processing and high-speed, wide-bandwidth data transmission, as well as in user interface technology and in the processing, transfer and storage of information.

A medium-to long-term analysis suggests that physical and chemical research and application-oriented engineering R&D in the following fields also merits serious attention:

- Quantum behavior of electrons
- Properties of materials that have undergone atomic lattice manipulation or alteration
- Micro-functional properties of biological structure

Practical research activities are being conducted in *The Creation of Materials for High-functional Opto-electronic Devices with a Liquid-drop Epitaxy Method* by the National Research Institute for Metals of the Science and Technology Agency, and *Quantized Functional Device R&D, "Superconducting Devices (R&D)", Biological Device R&D,* and other topics being pursued through the Ministry of International Trade and Industry's (MITI) Industrial Science and Technology Frontier Program. At The Ministry of Posts and Telecommunications, *R&D on Device Technology for Millimetric and Submillimetric Waves* by Communications Research Laboratory and *R&D on Molecular Device Technology for Advanced Telecommunications* as a part of the Frontier Research in Telecommunications are being promoted.

(2) Information Processing

Higher speeds and increased capacity promise implementation of advanced and highly functional information processing such as interpretation of information at a conceptual level and inference, learning and judgment by the function itself. Therefore, it is urgently required that not only computers be more sophisticated and functional, but also that advanced and higher software functions, algorithms, programming languages, and architecture based on a totally new concept, and open system formats be promoted.

Another important R&D field is the research on basic and fundamental technologies of neural network models and fuzzy logic systems that are essential in achieving capabilities such as understanding of imprecise expressions and knowledge, inductive reasoning, analogistic processing and learning. To this end, *Research Regarding the Construction of Self-organized Information Based Systems for the Purpose of Giving Creative R&D Assistance* and research on *The Development of Fundamental Technology for Sensor Fusion* are being conducted with funding allocated from the Special Coordination Funds for Promoting Science and Technology.

Table 3-4-1 Major research subjects in materials science and technology (in FY1994)

Ministry or agency	Research institute or program	Subject
Science and Technology Agency	Special coordination Funds for Promoting Science and Technology	* Frontier research on functional thin films * Research on new materials development based on nano-space phenomena * Development of assessment systems for reducing environmental impact and of designing concepts for environment friendly new materials and processing * Development of energy conversion materials through formation of gradient structures * Research on quantitative and intelligent nondestructive evaluation techniques for materials and structures of high reliability * Basic technology development of materials processing in a short-duration microgravity environments
	National Research Institute of Metals	* New superconducting materials * Intelligent functional and structural materials * Intermetallic compounds * Materials studies using ultra high vacuum * Material studies using extermely precisely controlled beams * Environment conscious materials * Biocompatible materials
	National Institute for Research in Inorganic Materials	* New superconducting materials * Super-diamond cubic boron nitride and single crystal diamond films * Materials processing in a short-duration microgravity environment * Intelligent functional and structural materials * Reseach on converting glass into intelligent optical material * Development of soft x-ray monochromator for SR applications for use as soft X rays * Thin film technology using reciprocal-type radical sources * Clay organic composites as earth friendly materials
	Institute of Physical and Chemical Research	* Frontier materials * Mesophase chemistry * Atom-scale sciengineering
	Research Development Corporation Japan	* Solid junction, polymer phasing, particle surface and other exploratory research for advanced technology * International joint research program on atom arrangement-design and control for new materials
Ministry of Education	National universities (through provision of grant-in-aid for scientific research and other funding)	* Exploring study of High-Tc superconductors based on the new strategy for material design * Intermetalic compounds as new high-temperature structural materials * Properties and functions of organosilicon and relalted group IVB catenate compounds * Science of high-temperature superconductivity
Ministry of Agriculture, Forestry and Fishery	Special research projects	* Study on wood-based hybrid construction materials for improving livability

(Table 3-4-1)

Ministry or agency	Research institute or program	Subject
Ministry of International Trade and Industry	Osaka National Research Institute, AIST	* Research of dynamic aspect of materials related to the advanced functions
	Electrotechnical Laboratory	* Material surface processing with controlled active beams
	Kyushu National Industrial Research Institute	* Development of noncombusible Mg alloys and semi-solid forming process
	National Institute for Resources and Environment	* Synthesis of layered polysilicates and utilization
	Chugoku Nationl Industrial Research Institute	* Surface evaluation by using fracto-emission and associated applications
	Mechanical Engineering Laboratory	* Processing technologies of super lattice materials
	Tohoku National Industrial Reseach Institute	* Synthesis and utilization of interstratified compounds
	National Industrial Reseach Institute of Nagoya	* Functional-composite particulate processing technology
	National Institute of Materials and Chemical Research	* Surface design of highly functional reactive devices
	Hokkaido National Industrial Research Institute	* Synthesis of new carbon-base composite
	Shikoku National Industrial Research Institute	* Intelligent technology of underwater plasma processing
	National Institute for Adranced Interdisciplinary Reseach	* Cluster science
Ministry of Posts and Telecommunications	Communications Research Laboratory and others (Frontier Research and Development for Next-generation Telecommunications Systems Program)	* Applications of superconductivity to telecommunications
Ministry of Labor	Research Institute of Industrial Safety	* Making new materials explosion- and flame-proof using static electricity

In addition, *Real World Computing* (RWC), *R&D for Open Basic Software Systems, R&D on Modeling a New Software Structure* based on the Industrial Science and Technology Frontier Program, and *Research Related to Flexible, Intelligent Processing* at the Electrotechnical Laboratory have been started by the Ministry of International Trade and Industry.

Furthermore *Research on Multi-dimensional Knowledge Functions for Next-generation Communication* at the Communications Research Laboratory, Ministry of Posts and Telecommunications, are being conducted based on the Frontier Research and Development for Next-generation Telecommunications Systems Program.

(3) Human Interfaces

Properly speaking, information systems are supposed to be tools to support and enrich human activity. But the current situation is that the human side must put in a great deal of effort to, accommodate the information system during operation. Thus, in order to sufficiently utilize the abilities of information systems, it is essential to build advanced human interfaces which think from a human standpoint and which anyone can easily operate according to his or her abilities. This can be achieved by basic research in cognitive science, which aims at understanding the information processing functions of human beings, and psychology applications research to support creativity, and other activities.

As research in this field, the Ministry of Posts and Telecommunications is conducting *The R&D Program on Network Human Interfaces and R&D on Information and Communication Systems for Groupware* as a part of the Frontier Research in Telecommunications. In the Ministry of International Trade and Industry, *The Future Personal Information Environ-*

ment Development (FRIEND 21), Human Media and the Mastering of Machine Technology based on The Industrial Science and Technology Frontier Program and other activities are being promoted.

(4) Information transmission

The information-oriented structuring of society has increased the dependence on telecommunications, necessitating research in high-speed, high-volume and more advanced telecommunications systems that support more sophisticated applications.

In cable-based telecommunications, coherent-light-wave optical communication systems using lasers have the potential to realize long-distance data transmissions with an exceptionally high volume.

In addition, research is being conducted on transmission technology based on new principles such as quantum optical transmission which is seen as the next generation of communications technology as well as new communications technology such as miniature transmission satellites and stratosphere wireless relay systems.

As advances in transmission capabilities, construction of a flexible network with diverse connectability and an intelligent network with various service functions to respond to sophisticated needs are expected, and at the Ministry of Posts and Telecommunications, ***R&D on Telecommunication Technology of 3-Dimensional Moving Pictures*** as a pioneering R&D program and ***Research on Sophisticated Intelligent Functions for Next-Generation Communication Systems*** as a part of Frontier Research in Telecommunications are being conducted.

(5) Application to Social Needs

R&D is underway for technology supporting medical care, education, production and cultural pursuits to realize an abundant and comfortable lifestyle, applying the technologies in (1) - (4) to human society. Concrete research is being conducted by MITI, such as research on Applied Technology for Measuring Human Senses, as a part of R&D in large scale industrial technology, and further R&D in this field is anticipated in the future.

Table 3-4-2 summarizes the major R&D subjects in information/electronics science and technology undertaken by the various government ministries and agencies during FY1994.

3.4.1.1.3 Life Sciences

The life sciences aim at elucidating the aspects of life in its many forms and complex and elaborate mechanisms involved. Research in the life sciences has the potential to contribute substantially to the solution of many problems related to health care, medical treatment, environmental conservation, and the agriculture, forestry, fishery, and chemical industries. The life sciences are fields looked upon with high expectations to make realistic large contributions to a healthy, enriched life for the people of Japan.

3.4.1.1.3.1 Basic Policies for the Promotion of Research in the Life Sciences

In 1971 the CST submitted its Recommendation pursuant to Inquiry No. 5, citing the importance of promoting research in the life sciences. After that, steady promotion of research in life sciences has been proceeding on the basis of recommendations of the CST including "Basic Program for the Research and Development on Leading and Fundamental Technology Life Sciences" which was approved by The Prime Minister in August 1984.

3.4.1.1.3.2 Promotion of Studies on the Human Genome (Genetic Code) Analysis

Human genome analysis is aimed at reading out the DNA sequence of the entire human genome. Today the analysis is a vital basis in the wide areas of life sciences which will bring about many benefits such as clarification, diagnosis, and treatments of cancer, Alzheimer's disease, and other diseases and the elucidation of the mechanism of evolution.

Table 3-4-2 Major research subjects in information / electronics science and technology (in FY1994)

Ministry or agency	Research institute or program	Subject
Science and Technology Agency	* Special Coordination Funds for Promoting Science and Technology	* Research to develop the fundamental technology of sensor fusion * Development of independently-organized information base systems to support creative research and development
	* Japan Information Center of Science and Technology	* New technology behind information dissemination
	* Institute of Physical and Chemical Research	* Research on photodynamics
	* Research Development Corporation of Japan	* Information on phases
Ministry of Education	* Subsidies for scientific research expenses (Priority Area research)	* Comprehensive processing of voice, language and concept for machine understanding and generation of dialog * A basic system for information processing based on the massively parallel principle * An Approach to KANSEI Information Processing from Information Science and Psychology * Quantum phase electronics
Ministry of International Trade and Industry	* Industrial Science and Technology Frontier Program	* Femto-second technology (cutting-edge research) * R&D of biological devices * R&D of models for structuring new software * R&D of quantized functional devices
	* Fifth generation computer technology project	* Development of new information processing technology
	* Electrotechnical Laboratory	* Research concerning integrated processing of multiphase information * Research concerning flexible, intelligent information processing * Network information centers
	* National Institute of Bioscience and Human-Technology	* Research concerning configurative operation properties in human interfaces * Research concerning measurement and engineering structures of human skills
	* Information-Technology Promotion Agency (IPA)	* R&D of open substrate software
Ministry of Transport	* Electronic Navigation Research Institute	* Research concerning an aircraft collision prevention system having a horizontal evasive function * Research concerning aircraft monitoring measures to shorten vertical control intervals * Research concerning utilizing GPS of aircraft
Ministry of Posts and Telecommunications	* Communications Research Laboratory and others (Frontier Research and Development for Next-generation Telecommunications Systems Program)	* R&D of High-efficiency Coding Technology through Models of Perception Mechanisms * R&D concerning fundamental technology for ultra-multi-dimensional plastic networks * R&D of unexplored electromagnetic waves * Research on multi-dimensional knowledge functions for next-generation communications * R&D of network human interfaces * Molecular Device Technology
	* Communications Research Laboratory	* R&D on device technology for millimetric and submillimetric waves * R&D on mobile radio communication systems using microwaves frequency band
	* Telecommunications Advancement Organization	* Communications technology involving advanced 3D image data and others

The Human Genome Committee is established under the Panel on Life Sciences of the Council for Science and Technology, for the further effective promotion of the Human Genome Analysis in Japan. The Committee issued a report in June 1994, to find tasks to be taken for the Human Genome Analysis urgently. The report sets the four specific objectives for R&D on the Human Genome Analysis, i.e. 1) promotion of DNA sequencing, 2) establishment of DNA resources for sequencing, 3) analysis of gene function and genome structure, and 4) technology development.

Following direction of the Committee, the Science and Technology Agency (STA) and other ministries carries out R&D on the Human Genome Analysis. STA carries out R&D for analysis of gene function and genome structure at the Institute of Phisical and Chemical Research (RIKEN), and shares the cost of development of the Genome Database (GDB) and established its Japan Node, and so on. In 1995 STA starts new initiative for mega-base sequencing with the contracts at the Japan Information Center of Science and Technology. The Ministry of Education carries out researches using the Grant-in-Aid for Scientific Research and consolidates the Human Genome Center at Institute of Medical Science of the University of Tokyo. The Ministry of Health and Welfare carries out analysis of human genes related to disease and aging. The Ministry of Agriculture, Forestry and Fisheries carries out researches about rice and cattle genome, and facilitates the DNA bank to conserve and to distribute fruits of forementioned reseaches. And also the Ministry of International Trade and Industry carries out foundamental R&D related DNA.

With these activites, various disciplines researchers' intrests and efforts concerning the Human Genome Analysis are stimulated. As results of these activities, sequence-ready DNA materials have being for the biologically more impotant regions and cDNA analysis of human and model organisms has greatly progressed.

3.4.1.1.3.3 Promotion of Recombinant DNA Research

Recombinant DNA experiments are important not only for the basic research on biology but also for improving the quality of life by assisting in determining the cause of diseases, manufacturing pharmaceutical compounds, developing micro-organisms for specific applications and breeding new varieties of crops. On the other hand, their potential ability to create new or altered life needs careful handling.

The CST responded to a governmental inquiry on the safety of experiments in recombinant DNA in its 1979 Recommendation pursuant to Inquiry No. 8, *Basic Policies for the Promotion of Research in Recombinant DNA*. Based on this, the Prime Minister enacted *Guidelines on Recombinant DNA Experimentation* the same year and R&D activities were started within this framework. The guidelines have been amended each time knowledge increases in the field. In September 1991, the 9th amendment was made due to an overall review of the guidelines based on progress in gene transfer technology and other areas. The CST plans to continue to review the Guidelines to meet the increase of knowledge and requirements in research ensuring safety in the experiments.

In 1978, the Science Council of the Ministry of Education proposed its own set of guidelines to ensure the safe, smooth progress of research on recombinant DNA at the national universities and associated institutions. *The Guidelines,* which take into account recommendations from experts in the field, were first published in 1979 and have subsequently undergone eight revisions as a result of further deliberations within the Council.

In considering the use of recombinant DNA technology at the stage of commercialization, the Ministry of Health and Welfare, the Ministry of International Trade and Industry and the Ministry of Agriculture, Forestry and Fisheries have issued guidelines for R&D under their respective jurisdictions.

The Ministry of Health and Welfare set "Guidelines for Gene Therapy Clinical Research" for the clinical research on gene therapy in April 1993 at The Health Sciences Council. Then, in February 1994, it announced the guidelines, and in the same month, in order to assure the scientific validity and ethics of the clinical research, inaugurated "Central Evaluation Council for Gene Therapy Clinical Research" to deliberate on individual operation plans.

In April 1994, the Ministry of Education also inaugurated "The Expert Committee on Gene Therapy Clinical Research" within its Science Council, in order to secure the appropriate operation of the clinical research on gene therapy at institutions such as universities, followed by announcing the Guidelines in June 1994.

The first gene therapy was approved under these committees in February 1995.

3.4.1.1.3.4 Promotion of Research on the Brain and Nerves

The brain is an information-processing organ made up of many nerve cells which administers high-order functions such as recognition, thought, emotion and will. The determination of brain and nerve functions means the clarification of their high-order functions from molecular and cellular levels to the individual level, and is indispensable to build a prosperous societal life. In addition, it is also hoped to contribute to the clarification, treatment and prevention of brain, nerve and mental ailments and to the creation of information processing systems based on new principles.

In 1987, the CST's Views concerning Basic Policy for Promotion of Science and Technology on the Brain and Nerve System indicated the policies to be promoted in order to set and meet important R&D goals, including the ascertainment of brain and nerve functions, and the determination of the causes and the development of prevention, diagnosis and treatment methods for brain and nervous system disorders. Later, under the conditions of progress made by subsequent R&D, in their Policy for Promoting General R&D for Basic Studies in Determination of Brain and Nerve Functions (Recommendation No. 19) of June 1994, Council for Aeronautics, Electronics and other Advanced Technologies pointed out that there is a necessity for not only a series of R&D studies from the molecular/cellular level to the system and higher-order function levels, but also for multi-faceted approaches and new technological developments. The Science and Technology Agency has been newly initiating Neuronal Function Research in addition to Research on Brain Mechanism of Mind and Behavior and Research on Brain Information Processing, and starting to design Frontier Neuro Science Research Facilities (tentative translation) in order to further these projects at international frontier research systems at the Institute of Physical and Chemical Research. In addition, the Special Coordination Funds for Promoting Science and Technology will be utilized to start Research on Development of Fundamental Technology Elucidating the Molecularmechanisms of Higher Brain Functions in FY1995. Then the Ministry of Education is promoting research on higher-order information processing in the brain, the Ministry of Health and Welfare is promoting research on illness in mental state and nerves, the Ministry of Posts and Telecommunications is promoting R&D on neuro-computing for auditory and visual information processing, and the Ministry of International Trade and Industry is promoting research on bio-electric devices. Furthermore, the Human Frontier Science Program (HFSP) has been providing international assistance for brain function research since 1990.

Table 3-4-3 summarizes the major R&D subjects undertaken by the various government ministries and agencies during FY1994.

Table 3-4-3 Major research subjects in life sciences (in FY1994)

Ministry or agency	Research institute or program	Subject
Science and Technology Agency	* Special Coordination Funds for Promoting Science and Technology	* Research on fundamental technology for structural and functional analysis of glycochains
	* Institute of Physical and Chemical Research	* Research on biological functions of living organisms such as human genome analysis * Bio-homeostasis research program, research program on brain mechanisms of mind and behavior, photodynamics research program, and bio-mimetic research program * Promotion of recombinant DNA experimentation * Gene bank projects
	* Research Development Corporation of Japan	* Exploratory research for advanced technology such as cell configuration, geno SHERE, protein array and so on * Precursory Research for Embryonic Science and Technology System such as cells and information ("Sakigake 21" research) * Evolution of microorganisms by international joint research projects
	* National Institute of Radiological Sciences	* Application of heavy ion beams to the medical field
	* Japan Atomic Energy Research Institute	* Research into the utilization of radioactivity for biotechnology
Environment Agency	* National Institute for Environmental Studies	* Research concerning effective use and environmental assessment of biotechnology for preservation of the environment * Research on understanding and conserving aquatic ecological systems within enclosed areas of sea
Ministry of Finance	* Research Institute of Brewing	* Research concerning structure and functions of organic cells involved in brewing and distillation
Ministry of Education	* National universities (through provision of grant-in-aid for scientific research and other funding)	* Overview of special studies on cancers * Molecular-biological research on cell replication control * New perspective on the RNA functional structure * Penetration of protein through membranes and the molecular mechanism of selected transportation * Mechanism of pain transmission and endogenous activated substances * Molecular structure of the environmental response of photosynthesis
Ministry of Health and Welfare	* National Institute of Health	* Mechanisms in molecular genetics behind the outbreak of infectious diseases and associated methods of prevention and treatment against them * Molecular Analysis of protozasis and chlamydiasis, and development of animal models for the infectious diseases
	* National Institute of Leprosy Research	* Analytical research on specificity, structure and function of protein produced by leprosy bacillus
	* National Institute of Hygienic Sciences	* Research on developing poison indices for fast and precise safety evaluations * Chemical study on biologically active stereoisomers for the evaluation of enantiomeric drugs
Ministry of Agriculture, Forestry and Fisheries	* National Institute of Agro- biological Resources * National Institute of Agro- Environmental Sciences * National Institute of Animal Industry * National Grassland Research Institute * Fruit Tree Research Station * National Research Institute of Vegetables, Ornamental Plants and Tea * National Institute of Sericultural and Entomological Science * National Institute of Animal Health * National Foods Research Institute * Forestry and Forest Products Research Institute * Regional Fisheries Research Laboratories	* Analytical research on rice genome * Analysis of animal genomes * General research in biotechnological plant breeding * General research to develop new agricultural, forestry and fishery techniques through the clarification and control of biological information * General research to elucidate the ecological order in the agricultural, forestry and fishery systems and develop optimal controls * MAFF gene bank project * Research project on the development of insect technology * Comprehensive research to develop high-functional materials through structural changes of sugar * Development of assessment techniques to enable advanced uses of recombinant organisms * Research projests to foster advance biotechnology techniques

(Table 3-4-3)

Ministry or agency	Research institute or program	Subject
Ministry of International Trade and Industry	* Industrial Science and Technology Frontier Program * National Institute of Bioscience and Human Technology	* Research and development on technology of production and use of compound polysaccharide * Design, Structure and Function of Protein-unit Assemblies * Study on Isolation, Function Analysis and Application of Biological Substances in Hypothalamus
	* National Institute Research Institute of Nagoya	* High Performance Ceramics for Bio-functional Control * Biocatalyst for Oxidation in Microacueous System
Ministry of Posts and Telecommunications	* Communications Research Laboratory and others (Frontier Research and Development for Next-generation Telecommunications Systems Program)	* R&D of High-efficiency Coding Technology through Models of Perception Mechanisms * Molecular Device Technology * Elucidation of Biological Functions
Ministry of Construction	* Public Works Research Institute	* Research concerning Actual Use of Sophisticated Treatment Processes using Fixation Microorganisms

3.4.1.1.4 Soft Science and Technology

3.4.1.1.4.1 Decision of the Basic Plans for Research and Development

Science and technology is facing a period of major change in this complex, advanced society where support for intelligent action is desired; a place where we have broken the shackles of a possession oriented mass production/mass consumption society and come to desire a high-quality, enriched and unhurried lifestyle. It has become essential to place importance on "humans and society".

In December 1992, a report in reply to CST Request No. 19 *Basic Plans for Research and Development on Soft Science and Technology,* was submitted as a strategy in response to this type of period/situation. The Prime Minister decided upon this as a fundamental plan for soft science and technology in January 1993.

In the Basic Plans for Research and Development, soft science and technology is designed to develop the capacity and functions of people, society, hardware and other practical matters. In other words, it promotes a system of science and technology that considers how hardware should be structured and moved and how intellectual abilities of humans and the industrial capacity of society should be supported and activated, and indicates important research and development issues and promotional policies. The following is a summary.

- Basic thinking
  In recognition of the growing importance of soft science and technology and the deepening and expanding of knowledge and technology that support it, the following should be emphasized in the promotion of research and development:
  —Emphasis on basic research (human features)
  —Planned promotion of research and development
  —Promotion of integration between natural sciences and human and social sciences.
- Important research and development issues based on the understanding of human qualities, including intellectual qualities and feelings, the following issues can be indicated:
  —Support of intellectual activities, improvement in comfort of living environment, understanding of complex social issues
  —Realization of hardware that gives priority to humans and harmonizes with society. Understanding the indistinct nature of human thought and activities and other important basic areas provide the key to the development of all of these.
- Promotion policies

The following measures are being taken for the promotion of soft science and technology which forms the new comprehensive science and technology:

- —Enhancement of a research and development center that forms the structure and core for the cooperation between researchers from a broad area of disciplines ranging from natural sciences to human and social sciences.
- —Enhancement of high-speed, large-capacity, advanced information processing facilities, information and communications networks, and other research and development bases.
- —Education of people with well-rounded knowledge through an environment in which knowledge from other disciplines can be obtained.
- —Building of a research and development structure that meets the needs of the users.
- —Enhancement of measures for promoting international exchange and cooperation.

Furthermore, the Resource Council, an advisory group to the Director-General of the Science and Technology Agency (Minister of State), has been grappling with policy for the importance, current conditions, future outlook and future development of intellectual technology (technology to support or replace human intellectual activities) since July 1992.

3.4.1.1.4.2 Promotion of Research and Development

Since the field of soft science and technology is still in its infancy,a Soft Science and Technology Promotion Committee comprised of the relevant persons from industry, universities and national research institutes, as well as learned persons in the humanities and social fields, was held in 1994 in order to consider comprehensive promotion policies. Here, the researchers and the users of the fruits of that research came together, discussed such topics as the future of soft science technology R&D, promotion policies, and the future feedback from the actual society in attempt to reach a consensus.

3.4.1.1.4.3 Current State of Research and Development

Soft science and technology shows great promise as a basic, leading area that can bring new breakthroughs and integrate human and social sciences with natural sciences. In recent years, there has been an increase in research and development activities accompanying the re-ordering of science at research organizations and universities involved in soft science and technology.

The main research topics addressed in soft science and technology in FY1994 are shown in Table 3-4-4.

3.4.1.1.4.4 Current State of International Exchange

When promoting R&D, efforts are also made to promote international exchange and cooperation. To this end, in FY1994, regarding the results of R&D in each country, with the goal of discussing each country's results and exchanging information regarding the current state of R&D, a Japan-UK international workshop regarding soft science and technology, and an International Symposium on Creative Assistance in Intellectual Production Activities, were held.

3.4.1.1.5 Advanced Fundamental Science and Technology

As science and technology develops and becomes more complicated in each area, the importance of having technology which can become a common foundation utilized in different areas and be a key to further development in those areas has been recognized. For example, the promotion of technology to measure and handle extra-microsubstances and expansive spaces with ultra-high precision, technology to make and display real time, multi-dimensional observations, and the support of other measurement and analysis technologies are considered important.

Table 3-4-4 Major research subjects in soft science and technology areas (in FY 1994)

Ministry or agency	Research institute or program	Subject
Science and Technology Agency	Special Coordination Funds for Promoting Science and Technology	* Fundamental Researches on Human Characteristics for Harmonizing Systems with Human Beings * Basic Researches for Intellectual Facilitation of Creative Activities * Survey on the Developmental Mechanism of Various Social Activities and their Effective Support
	Japan Atomic Energy Research Institute	* Development of Evaluation Method of Reliability of Human Behavior
	Institute of Physical and Chemical Research	* Research Program on Brain Mechanisms of Mind and Behavior
Environment Agency	Research Funding to the National Research Institute engaged in Environmental Pollution Research	* General research on environmental management and conservation
Ministry of Education	Grant-in-aid for scientific research and other funding (Special Promotion Projects, Priority Area Research)	* National and chronological studies of voting behavior * An Approach to KANSEI Information Processing from Information Science and Psychology
Ministry of Agriculture, Forestry and Fisheries	Separate general research	* Development of Techniques for the Evaluation and Application of Functions of Agricultural, Forest, and Fishery Products that Contribute to Health
	Comprehensive research and development	* Fundamental research and development into agricultural technology to reduce labor input
Ministry of International Trade and Industry	Industrial Science and Technology Frontier Program	* Human Sensory Measurement Application Technology * Technology of human media and machine proficiency (cutting-edge research) * Technology of measurement and evaluation of dynamic characteristics and nature of elderly people * Understanding information processes involved in intelligent behavior by measuring brain functions
Ministry of Transport	Research and Development on Transportation Technology Promotion	* Technology to facilitate use of public transport facilities by elderly and physically disabled persons
Ministry of Posts and Telecommunications	Communications Research Laboratory and others (Frontier Research and Development for Next-generation Telecommunications Systems Program)	* Realization of Highly Intelligent Functions * R&D of network human interfaces
Ministry of Construction	General research and development	* Creative technology for esthetically pleasing surroundings

On the other hand, new types of fundamental technology which combine the science and technology of existing areas such as micro-engineering technology which integrates microelement device technology, micro-control technology and micro-design technology, are being developed. Ministry of International Trade and Industry are conducting R&D on "Micromachine Technology" based on the Industrial Science and Technology Frontier Program.

Furthermore, in order to solve the complex problems surrounding the activities of mankind and to achieve harmony between human beings and the natural environment, and between human beings and society, it is becoming increasingly important to combine various fields of research and conduct basic research in such areas as the development of: permanent production methods which less affect the global environment; systems which have complex machines but can be operated without difficulty; and building techniques for mechanical systems that will cope with an aging population.

It is expected that this advanced, fundamental science and technology will provide breakthroughs to issues which could not be solved through the development of new application areas or with conventional approaches by encouraging the mutual exchange of science and technology in differing areas.

Therefore, advanced fundamental science and technology is ranked as a main area in the basic and pioneering science and technology in the Recommendation Pursuant to Inquiry No. 18 of the CST and the Basic Policy for Science and Technology Policy and will be promoted. In addition, the Science and Technology Agency started The Survey Concerning the Future Direction of R&D for Advanced Fundamental Science and Technology from 1992 for two years through the Special Coordination Funds for Promoting Science and Technology, and will extract concrete research topics from advanced fundamental science and technology areas which should be promoted in the future and the various factors obstructing the promotion of such research, and will clarify the direction in which advanced fundamental science and technology should be developed.

In FY1993, the Special Coordination Funds for Promoting Science and Technology enabled the initiation of development of basic technology for the development and use of critical quantum sensing.

The Ministry of International Trade and Industry has formed a research and development system for industrial science and technology to conduct research and development on atomic technology for securing technology for closely monitoring and operating each atomic particle.

Investigative research in "femto-second technology," which uses, for engineering purposes, ultra-high speed phenomena which occur at the one quadrillionth (10^{-15}) of a second level have also been conducted.

In view of these circumstances, in order to promote plans for research and development in leading basic science and technology, the Office of the Prime Minister asked the Science and Technology Council to conduct investigations for the enactment of a basic plan in response to Request 21 on Basic Plans for Research and Development on Leading Basic Science and Technology. On December 12, 1994, a reply was sent, and on December 27 the Basic Plans for Research and Development and Leading Basic Science and Technology was settled.

The main research subjects undertaken in advanced fundamental science and technology are shown in Table 3-4-5.

3.4.1.1.6 Space/aeronautical Science and Technology

3.4.1.1.6.1 Space Development

Space development plays an important role in furthering science and technology and improving the quality of people's lives through its contributions in areas such as scientific observation, communications, broadcasting and meteorological observation.

Japan's space development bas been conducted under the cooperation of organizations including the National Space Development Agency of Japan and the Institute of Space and Astronautical Sciences. Activities are based on both the Fundamental Policy of Japan's Space Development (published in 1978, revised in February 1984 and June 1989) and the Space Development Program, which specifies the annual development plans in accordance with the Fundamental Policy, as prescribed by the Space Activities Commission.

In this Fundamental Policy, the following three directions are pointed out as basic principles for Japan's space development policy:

- Response to advancing and diversifying needs
- Consistency with Japan's role in the international society to improve the nation's capability to continuously and freely conduct various space activities and international cooperation
- Encouragement of the private sector in the space development

Table 3-4-5 Major research subjects in advanced fundamental science and technology (in FY 1994)

Ministry or agency	Research institute or program	Subject
Science and Technology Agency	Special Coordination Funds for Promoting Science and Technology	* Fundamental research into development and application of limiting quantum sensing technology
	Research Development Corporation of Japan	* Quantum fluctuation, atomic regulation surface
Ministry of Education	Through provision of grant-in-aid for science research and other funding (Special Promotion Projects)	* Photofabrication microactuator * Developing electron microscopes using metastable atoms as probes and associated solid surface applications
Ministry of Health and Welfare	Subsidies for research welfare science	* Analyzing links between molecular design and structural activity in pharmaceuticals * Technology for measuring, analyzing and controlling data on organisms
Ministry of International Trade and Industry	Industrial Science and Technology Frontier Program	* Micromachine Technology * Technology for limiting manipulation of atoms and molecules * R&D on quantized functional devices * Elements with quantization function * Ultra-advanced processing systems
	National Research Laboratory of Metrology	* Femto-second technology (cutting-edge research) * Ultra-high resolution spectra via atomic and ion cooling * High-precision measurement techniques using trace water content in gas
	Mechanical Engineering Laboratory	* Technology for creating wide-area super-dense surface contours
	Electrochemical Laboratory	* Nanostructures * Technology of advanced light wave control
	National Institute of Materials and Chemical Research	* Separating physical matter with electro-magnetic fields and high-sensitivity measurement technology
	National Institute for Advanced Interdisciplinary Research	* Biotechnique design
Ministry of Posts and Telecommunications	Communications Research Laboratory	* R&D of high precision technology measuring time and space with cosmic radio waves

In July 1994, Special Committee on Long-term Vision of Space Activities Commission reported its conclusion, *Toward Creation of Space Age in the New Century,* based on such factors as changes in the international situation regarding space development, and domestic and foreign progress in the utilization of space development. In response to this report, Space Activities Commission established Special Committee on Long-term Policies in February 1995 and survey and deliberation on revising on the Fundamental Policy of Japan's Space Development are under way at the Committee.

(1) Satellites

Since the successful launch of Japan's first satellite, Ohsumi, in 1970, Japan has successfully launched 58 satellites by March 1995, and ranks third following the United States and the former Soviet Union.

The following sections describe the main satellites. Table 3-4-6 provides a full listing of satellites and payloads launched during FY1994, and those planned to be launched in FY1995 and thereafter.

①Scientific Field

The Institute of Space and Astronautical Science affiliated to the Ministry of Education, in cooperation with universities nationwide, has launched scientific satellites so far. These include the magnetosphere observation satellite GEOTAIL, a collaborative program with NASA, intended to observe the structure and the dynamic of the extended tail of the magnetosphere on the night-side of the Earth, and the 15th Scientific Satellite ASTRO-D which investigates X-ray precision imaging and spectrum observation of heavenly bodies at the far-edge of space.

Table 3-4-6 Satellites and payloads launched during FY 1994 and thereafter

Satellite / payload	Weight (kg)	Orbit	Orbital altitude (km)/ location	Launch vehicle	launch date (fiscal year)	Major objectives
∗ FY 1994						
ETS-VI engineering test satellite-VI	Approx. 2,000	Elliptical orbit	Approx. 8,560 to 38,700	H-II	Aug. 28 1994	∗ Confirmation of H-II test rocket performance ∗ Further development of large-scale geo-stationary 3-axis satellite bus technology required for the development of satellites in the 1990s ∗ Development of technology and testing of high-performance satellite communications systems
SFU space flyer unit	Approx. 4,000	Circular orbit	Approx. 480	H-II	Mar. 18 1995	∗ Various scientific and engineering experiments ∗ Astronomical observations ∗ Acquiring the opportunity required for the R&D of advanced industrial technologies ∗ Reliability testing and improvement of exposed facility of JEM common experiment equipment
GMS-5 geostationary meteorological satellite 5	Approx. 340	Geostationary orbit	—	H-II	Mar. 18 1995	∗ Improvement of weather observation ∗ Development of meteorological satellite technology
∗ Satellites and payloads to be launched during FY 1995 and after according to “Space Development Plan (June 13, 1994)”						
ADEOS advanced earth observing satellite	Approx. 3,500	Sun synchronous sub-recurrent orbit	Approx. 800	H-II	1995	∗ International cooperation in monitoring global environmental changes ∗ Development of technology which will be required by the next generation of earth observation plat forms and similar satellites ∗ Development of the technology required for the relaying earth observation data
MUSES-B The 16th Scientific Satellite-Mu Space Engeneering Satellite-B	Approx. 800	Extended elliptical orbit	1,000 to 20,000	M-V	1996	∗ Large-scale precision development structure organization research and radio astronomy observation
COMETS communications and broadcasting engineering test satellite	Approx. 2,000	Geostationary orbit	—	H-II	1996	∗ New technologies of sophisticated moving-body satellite communicationstechnology, inter-satellitescommunications technology and sophisticated satellite-broadcasting technology in the communications and broadcasting areas, multi-frequency bandwidth integration technology and efficiency-increasing technology of large-scale stationary satellites will be developed, experimented with and demonstrated
ETS-VII engineering test satellite-VII	Approx. 2,600	Circular orbit	Approx. 550	H-II	1997	∗ To develop technology such as rendezvous-docking and remote operation and conduct pioneering experiments related to space robot development
TRMM (Tropical Rainfall Measuring Mission)	Approx. 3,600	Circular orbit	Approx. 350	H-II	1997	∗ Monitoring of tropical rains necessary for explaining global energy use mechanisms
LUNAR-A 17th scientific satellite	Approx. 520	Circular orbit	100km over the moon surface	M-V	1997	∗ Elucidation of crustal structure and thermal structure of the moon
OICETS optical inter-orbit communications test satellite	Approx. 500	Circular orbit	Approx. 550	J-I	1998	∗ To acquire inter-satellite link-up technology by optical science

(Table 3-4-6)

Satellite / payload	Weight (kg)	Orbit	Orbital altitude (km)/ location	Launch vehicle	launch date (fiscal year)	Major objectives
PLANET-B 18th scientific satellite	Approx. 536	Orbit around Mars	Approx. 150 to 34,000	M-V	1998	* Investigation of the atmospheral structure and movement of Mars and its mutual interaction with solar wind
ADEOS-II advanced earth observing satellite-II	Approx. 3,500	Sun synchronous sub-recurrent orbit	Approx. 800	H-II	1998	* Obtaining earth science data necessary for elucidating global water/energy cycle mechanisms associated with global environment problems
multipurpose transportation satellite	—	Geostationary orbit	—	H-II	1999	* Acquiring the continuation of meteorological satellites * To improve air traffic safety and efficiency
ASTRO-E 19th scientific satellite	Approx. 1,300	Approximate circular orbit	Approx. 500 to 600	M-V	1999	* Investigation of high-energy astronomical phenomena and cosmogony by observing X-rays
JEM Japanese experiment module	Undecided	—	400	U.S. Space Shuttle	1999	* Expansion of Japan's space activities, promotion of leading science and technology development, and contribution to the advancement of international cooperation

Other scientific satellites currently under development include the following:

1) The 16th Scientific Satellite MUSES-B is designated to investigate the deployment of a large dexterous structure and make astronomical observations by radio waves for Space VLBI.
2) The 17th Scientific Satellite LUNAR-A is being designed to elucidate the intra-lunar crustal and thermal structure.
3) The 18th Scientific Satellite PLANET-B is intended to investigate the atmospheral structure and movement of Mars and its mutual interaction with solar wind.
4) Development of the 19th Scientific Satellite (ASTRO-E) for the purpose of observing X-rays emitted from the active galaxy core

②Earth and Meteorological Observation

Regarding *The Himawari series* of geostationary meteorological satellites, Himawari 5 was launched on March 18, 1995, and is currently in operation.

Furthermore, the launching of a multi-functional transport satellite equipped with functions of meteorological mission in addition to functions of air-traffic control mission is planned for 1999 by the H-II launch vehicle.

The Momo series of marine observation satellites are used to observe the color and temperature of the ocean surface and other ocean phenomena. MOS-1b (*Momo 1b*) launched on February 7, 1990, are presently in service. Other satellites currently in operation or being developed are the following:

1) Japanese Earth Resources Satellite JERS-1, launched on February 11, 1992, is expected to obtain data useful for earth observation to contribute to land survey, agriculture, forestry, fishery and so on.
2) The Advanced Earth Observing Satellite ADEOS which uses platform technology, intends to monitor global environmental changes and to promote further international cooperation in the field of earth observations. ADEOS is under development and is scheduled for launch in FY1995.
3) The Tropical Rain-fall Measuring Mission TRMM, through Japan-U.S. cooperation, intends to monitor rain-fall in the tropics which is vital to elucidating the mechanism

of energy balance on a global scale.

4) The Advanced Earth Observing Satellite (ADEOS-Ⅱ) intends to succeed and improve wide area earth observing technology using platform technology.

③Communications and Broadcasting

The Sakura series of communications satellites, CS-3a (*Sakura 3a*), launched on February 19, 1988, and CS-3b (*Sakura 3b*), launched on September 16, 1988 are currently operational.

As for the *Yuri series* of broadcasting satellites, BS-3a (*Yuri-3a*) which was launched on August 28, 1990, and BS-3b (*Yuri-3b*) which was launched on August 25, 1991, are currently operational.

The development of the Communications and Broadcasting Engineering Test Satellite (COMETS) is proceeding with the purpose to develop, experiment with, and demonstrate technology of advanced mobile satellite communications, inter-satellite communications, high-performance satellite broadcasting' multiple frequency-band integration and higher-performance largescale geostationary satellites.

In terms of effective optical communications technology for satellite communications systems, development is being conducted in cooperation with the European Space Agency (ESA) on the Optical Inter-orbit Communications Engineering Test Satellite (OICETS) which is designed to conduct experiments in orbit on essential technology focusing on the link-up with the static satellite ARTEMIS of the European Space Agency (ESA).

④General Satellite Technology

The Kiku series of engineering test satellites are used to test common technologies of variety types of satellites. The engineering test satellite ETS-V (*Kiku 5*) which was launched on August 27, 1987, designed to test mobile communication technology, is in operation. The following satellites are under development:

1) With the aims of verifying the performance of the H-Ⅱ launch vehicle test unit and the establishment of large stationary triaxial satellite bus technology needed for the development of an application satellite in the 1990s, the 6th Engineering Test Satellite, "Kiku-6", launched on August 28, 1994, to develop technologies and conduct experiments for advanced satellite communications with respect to fixed, mobile and inter-orbit communications, but due to a trouble of its apogee engine, geostationary orbit could not be achieved, and is remaining in an elliptical orbit. Committee on Special Investigation on Engineering Test Satellite-VI of Space Activities Commission conducted investigations to ascertain the cause of Engineering Test Satellite-VI (Kiku 6)'s failures and to come up with countermeasures for the future,which it detailed in its report in December 1994. The National Space Development Agency of Japan is now discussing the concrete measures pointed out in the report. Although Kiku 6 cannot achieve its original objectives due to its different orbit and shortened operation time, it is still executing various experiments and preparing the results.

2) The 7th Engineering Test Satellite ETS-VII will be used to acquire basic technologies of rendezvous, docking and space robotics that are essential to the future space activities through in-orbit experiment.

(2) Launch Vehicles

①M series rockets

For launching scientific satellites, the M (mu) series rockets have been developed, succeeding the L (lambda) series rockets. M series launch vehicles use solid propellants for all stages. Currently, regarding the M-3 SII, eight rockets have been launched to date. Although M-3SII rocket No. 8 was launched on January 15, 1995, due to failure in the rocket, Experiment Re-entry Space System (EXPRESS) could not be put into its appointed orbit. Then , Subcommittee on M-3SII Rocket was set up within Committee on Technology Assessment SAC to investigate and ascertain the cause of the problem and come up with countermeasures for the future. At present, development of the three-stage M-V launch vehicle, with enlargement of each stage and a simpler configuration, is underway to meet the requirements of scientific observation missions after the 1990s.

②H-II rockets, J-I rockets

Regarding launch vehicles for satellites, after completing development of the N series rockets, H-I rockets, the H series rockets have been developed. The H-II launch vehicle is a large two-stage vehicle being developed to launch two-ton class geostationary satellites to meet the satellite demand of the 1990s. This launch vehicle uses liquid-hydrogen/oxygen engines in both stages. The first test launch of the H-II was ended in success on February 4, 1994. Two more successful launches took place on August 28, 1994 and March 18, 1995. Advancements on the H-II launch vehicle are being made with an eye toward reducing costs while maintaining reliability. And to deal with demands for launching small payload reasonablly, development of the J-I launch vehicle which can transport oneton payloads into a low earth orbit, is also being developed, with the goal of a first launch within FY1995. (Table 3-4-7).

③The test unit of the experimental HOPE

The test unit of the experimental HOPE are geared toward the early establishment of the major technology for unmanned winged space transfer-and-return vehicle(HOPE) that make possible the transport and recovery of supplies to space station. The research is being advanced toward the launching by the H-II launch vehicle before the end of this century.

(3) Space Utilization and Manned Space Activities

①First material processing test *(Fuwatto '92)*

In September 1992, Japanese astronaut Mamoru Mohri boarded the U.S. Space Shuttle Endeavor and launched into space for about eight days where he used the special characteristics of the space environment to conduct Japan's Fuwatto '92 experiment covering 43 themes of investigation: 22 related to materials experiments of Japan, 12 related to life sciences experiments of Japan and 9 related to U.S. experiments. This mission will provide an important opportunity to acquire the technology needed for manned space flights.

②International Microgravity Laboratory (IML) program

In order to amass the technology and experience necessary for participation in the Space Station Program, through international cooperation, the US Space Shuttle was used to run the First International Microgravity Laboratory (IML-1) program for about eight days starting on January 22, 1992. Two types of experiment apparatuses were contributed by Japan and were used in the experiments.

Table 3-4-7 Main specification of vehicles used to launch satellites

Launch vehicle type	Stages	Overall length (m)	Diameter (m)	Gross Weight (tons)	Propellant
M-3SII	3	27.8	1.41	Approx. 61	Solid for all stages
M-V	3	Approx. 30	2.5	Approx. 128	Solid for all stages
H-II	2	Approx. 50	Approx. 4	Approx. 264	1st and 2nd stages, liquid oxygen / hydrogen; SRB, Solid
J-I	3	Approx. 33	Approx. 1.8	Approx. 87	Solid for all stages

The first female Japanese astronaut, Chiaki Mukai, boarded the 15-day flight on the space shuttle Columbia in July 1994, in which life science experiments on eight themes and material experiments on four themes proposed by Japan were conducted.

③Space Station Program

The Space Station Program is an international project in which the U.S., Europe, Canada and Japan participate in the goal of constructing a manned space station in a low earth orbit at an altitude of 400km. The space station will establish the infrastructure for utilizing the space environment and for furthering manned space activities.

Japan has been developing Japanese Experiment Module (JEM) and Japanese astronauts will be stationed on board for a long period. On September 5, 1989, Japan signed the Inter-Governmental Agreement, which sets up a cooperative framework after the detailed design stage of the program. The agreement was followed on January 30, 1992 by the U.S. to make the agreement effective from that date. Japan's space station project has already entered the full-scale development phase.

Later, in December 1993, after the international situation had changed, Japan, the US, Europe and Canada jointly invited Russia into the program, and Russia's participation was declared. In March 1994, the baseline of the technical aspects regarding the overall structure of the new Space Station Program with Russia's participation was agreed to by each space organization.

④Others

With an aim toward: securing opportunities for experiments in outer space for the purpose of executing various types of scientific research, including science and engineering experiments and astronomical observations; and developing various frontier industrial technologies, along with improving the reliability of the exposed section and the on-board common experimental equipment of the JEM for linking with space stations, recoverable, reusable Space Flyer Units (SFU), which can fly in a low earth orbit for several months at a time, launched on March 18, 1995, is currently in operation.

(4) Fundamental and Advanced Research on Satellite and Launch Vehicle Technology

The National Aerospace Laboratory and research institutes of related ministries and agencies are conducting fundamental research on launch vehicle and satellite technology. The laboratories and research institutes are also working in a number of advanced research areas, including the H-II orbiting plane (HOPE), an unmanned winged reusable space vehicle which can be used to transport cargo to the Space Station and a manned space-plane.

(5) International exchange in the area of space development

In light of the air of cooperation between the US and Russia in the wake of the end of the Cold War and the increasing importance of observations from earth observing satellites due to the severity of global environmental problems, there has been an increasing necessity for cooperation between the nations of the world in the field of space.

At the September 1994, ministerial conference on space applications of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), the initiation of "Regional Space Applications Program for Substantial Development in Asia and the Pacific (RESAP)" for the purpose of cooperation in space applications in the Asia-Pacific region was adopted. And a Space Cooperation Agreement was concluded between Russia and Japan during President Yeltsin's visit to Japan in October 1993.

In addition to the above, Japan participates in: the United Nations Committee on the Peaceful Uses of Outer Space, which conducts discussions on the establishment of an international order regarding investigations in and uses of outer space and the promotion of international cooperation; the Asia Pacific Regional Space Agency Forum (APRSAF), which conducts opinion exchanges regarding the future of space development; the Standing Senior Liaison Group (SSLG) with the United States; and executive conferences with the European Space Agency (ESA). Through these activities, Japan conducts multilateral and bilateral cooperation exchanging information and opinion with various countries.

3.4.1.1.6.2 Aeronautical Technology

R&D in aeronautical technology is knowledge-intensive and makes use of state-of-the-art technologies from a wide range of disciplines. As a result, developments in this field can promote advancements over a wide range of downstream technologies, in addition to the basic goal of improving the equipment and infrastructure for air transportation.

Given its technologically strategic nature, extensive R&D in aeronautics is critical to the overall promotion of science and technology and to the development of a technologically-oriented society.

The current state of the nation's aeronautical technology is the direct result of knowledge acquired through R&D on the Japanese-developed YS-11 commercial transport airplane, the international joint development of the Boeing 767 passenger jet and other aircraft. This technology is now at the stage where Japanese private sector corporations are participating or intending to participate in a number of domestic and international aircraft development projects, some of which are listed below.

- The design and manufacture of the 350-seat twin-engine Boeing 777 passenger jet
- The YSX, small-sized passenger aircraft
- Investigation for the development of the YSX, small-sized passenger aircraft and next-generation supersonic commercial transport aircraft

To actively promote the development of aircraft and their engines, it is necessary to enhance futuristic technological levels. To this end, the government is formulating measures designed to encourage R&D in this field in accordance with recommendations contained in reports prepared by the Council for Aeronautics, Electronics and Other Advanced Technologies.

In June 1994, the Council submitted the report on *Policy for long-term development of Aeronautical Technologies* (Request No. 18).

National Aerospace Laboratory of the Science and Technology Agency is promoting research with the goal of establishing the technologies required for futuristic aeronautics development. The laboratory has encouraged research on aerodynamics, structures, control, propulsion and other state-of-the-art aeronautical transportation technologies that will be required for future aircraft such as high-speed aircraft, unmanned winged space vehicle and space planes. Also, on top of promoting R&D on air-transport safty, environmental feasibility and basic technology such as numerical value simulations using computers, the laboratory maintains large-scale test research facilities for wind tunnel experiments, engines experiments, and so on to be jointly used by related agencies, and takes a leading role in advancing Japan's aerospace technology.

The Electronic Navigation Research Institute of Ministry of Transport is conducting R&D on navigation and air-traffic control systems to improve air safety. Findings from this research will ensure steady development of the air transportation system.

The Ministry of International Trade and Industry is furthering R&D of propulsion "Super / Hyper-Sonic Transport Propulsion System" capable of operating at low air speeds through Mach 5. European and American engine manufacturers are participating in this R&D.

3.4.1.1.7 Ocean Science and Technology

The development and use of the ocean, which contains an abundance of resources, including biological and mineral resources, as well as vast space, is an important issue for a country as physically small and confined by sea as Japan.

Because the ocean plays an important role in global change and the crustal dynamics of the earth greatly influence earthquake and volcanoes, it is urgent that mechanisms in and around the ocean be elucidated.

In light of these conditions, the United Nations Educational, Scientific and Cultural Organization (UNESCO) and Intergovernmental Oceanographic Commission (IOC) began to make calls in the 1990s for the GOOS plan which aims to build a system for conducting comprehensive observation and research of ocean phenomena on a worldwide scale. This plan was also promoted at Agenda 21, adopted by the United Nations Conference on Environment and Development held in Brazil in June of 1992.

Based on these international efforts, it is crucial to promote ocean research related to global environmental issues and other research and development on ocean science and technology.

3.4.1.1.7.1 Basic Guidelines for the Promotion of Ocean Science and Technology

The Council for Ocean Development is an advisory committee to the Prime Minister which decides basic and general concepts related to ocean development. The Council's Recommendation pursuant to the Prime Minister's Inquiry on *Basic Concepts and Promotional Guidelines for Long-term Ocean Development,* submitted in May 1990, identifies the following basic principles guiding the advancement of ocean science and technology.

- The promotion of oceanographic studies and development of technologies for the elucidation of global change and ocean phenomena.
- The promotion of science and technology which is useful for overcoming severe oceanic conditions and for creating new ways of ocean development.

The Council's December 1993 report submitted in response to the Prime Minister's inquiry on "Policies for Promoting Japan's Oceanographic Research, Including, the Development of Related Technologies and Infrastructure", specifically pointed out the following as important in advancing research technologies which can effectively deal with global environment issues:

- Strengthening the oceanographic research base including, among others the development of a large oceanographic observation and research vessel
- Systematic promotion of global-scale oceanographic research

Related government ministries and agencies are engaged in promoting R&D in ocean science and technology under their respective jurisdictions in accordance with the guidelines of the Council's recommendation. Further, the various ministries and agencies coordinate closely to ensure comprehensive promotion by following the Promotion Program for Ocean Development compiled annually by the Liaison Council for Ocean Development-related Ministries and Agencies.

Furthermore, in order to shed some light on ocean phenomena occurring on a global scale, positive efforts are being made to participate with related government agencies and universities in international ocean research programs such as GOOS.

3.4.1.1.7.2 Promoting R&D in Ocean Science and Technology

The Science and Technology Agency is promoting pioneering and fundamental R&D, mainly by the Japan Marine Science and Technology Center (JAMSTEC) and also by comprehensive projects with the cooperation of ministries and agencies concerned.

JAMSTEC is developing submersible vessels to provide information in areas related to exploration of the ocean floor, prediction of seismic activity, studies on deep-sea microorganisms, and is executing deep-sea explorations and studies. In FY1994 the Japan Marine Science and Technology Center (JAMSTEC) promoted deep-sea investigations and research activities with the manned research submersible SHINKAI 2000, SHINKAI 6500 and the remotely operated vehicle DOLPHIN 3K, and began development of a remotely operated vehicle which can dive to 10,000m KAIKO. In March 1995, KAIKO completed diving tests at the Mariana Trench, the deepest in the world (water depth = 10,911m). In addition, JAMSTEC started R&D on a deep-sea drilling vessel system to elucidate the plate tectonics and global environmental changes.

In ocean observation researches for clarifying ocean phenomena, not only the undertaking comprehensive research in Pacific Ocean tropical and Arctic Ocean regions and the development of observation technologies such as ocean lasers and ocean acoustic tomography, but also the building of a large oceanographic observation and research vessel which would make global-scale oceanographic research possible have been initiated. Also, JAMSTEC has promoted R&D on technology utilizing wave power and joint R&D projects with municipalities in each region to contribute to appropriate management and development of coastal areas.

The Science and Technology Agency also promotes comprehensive joint research projects among related ministries, agencies and universities. These joint research projects include research program on the Kuroshio to research the meandering flow of the Kuroshio and its large effect on weather and fishery around Japan and East Asia by allocation of The Oceanographic Development and Earth Science and Technology Promotion Funds; by allocation of the Special Coordination Funds for Promoting Science and Technology, research on global oceanic heat circulation and material flux.

Through the University of Tokyo Ocean Research Institute, the Ministry of Education has been conducting basic research related to GOOS, which aims to build a comprehensive observation system for explaining, predicting, and protecting shifts in the ocean environment; participating in the ODP, which excavates the ocean floor and helps to explain the movements and structures of the ocean floor plates, and joint surveys of the Pacific Ocean region; conducting ocean flux research and other academic research on the ocean which contributes to an understanding of the physical environment of the ocean.

The Ministry of Agriculture, Forestry and Fisheries, through the Fisheries Agency, is conducting R&D on the following areas.

- Rationalization of production in the fishing industry and utilization that helps maintain resources, through the introduction of new technologies and the grasping of the characteristics of marine product resources
- Promotion of fish farming
- Preservation of the fishing ground environment
- Diverse and advanced utilization of marine products

The Ministry of International Trade and Industry, through the Agency of Natural Resources and Energy and the Geological Survey of Japan, is developing ocean floor mineral resources predicting infuluence on ocean environment and carrying out geological surveys on the seabed.

The Ministry of Transport is conducting the following activities.

- Oceanographic observations for hydrographic services through the Maritime Safety Agency
- Research on material diffusion at ocean depths
- Meteorological observations at sea for meteorological operations and investigations and research on weather analysis and prediction such as the El Nino phenomenon, etc.

The Ministry of Posts and Telecommunications is using its Communications Research Laboratory to conduct high-resolution three-dimensional microwave radar research to confirm measuring and prediction technologies related to ocean oil pollution, ocean currents, and waves.

The Ministry of Construction is using its Public Works Research Institute to implement Study on Beach Stabilization and Sorting of Mixed Grain Size Sand as well as for Development of Coastal Environment Conservation Program in Tropical Zones. Its Geographical Survey Institute is conducting basic surveys of coastal sea areas, etc.

Table 3-4-8 summarizes the main R&D subjects undertaken by the various government ministries and agencies during FY1994.

3.4.1.1.8 Earth Science and Technology

A lot of researches to clarify the global phenomena have been done in the fields of atmosphere, hydrosphere, geosphere and biosphere. The development of surveillance technologies such as remote sensing technologies using observation satellites, numerical simulations technologies using supercomputers have contributed to the progress of researches on earth science and technology.

Thus mankind has explored the earth for a great number of years and reached a stage in recent years where knowledge on the earth and global phenomena is rapidly accumulating and comprehension of the earth as a single system has become possible. In addition to using these results for predicting global phenomena and sustaining the development of mankind, there have also been an increasing quest for knowledge of the unknown. Shifts in the global environment stemming from the increase in human activities, however, has also created major problems in the world. As a result, there has been a strong shift toward science and technology that changes the attitude of the earth as a limitless resource and provides a balance between humans and the global environment.

Based on these conditions, in August 1990, Japan responded to the conclusions of the Council for Science and Technology through a decision by the Prime Minister to adopt the Basic Plan for Research and Development on Earth Science and Technology which looks 10 years into the future. This plan outlines the necessary role and measures to be taken by the Government in deepening its understanding of the earth and using research results to promote the basic thinking for advancing research and development, important research and development issues, and the promotion of global science and technology that contribute to the prosperity of all mankind.

In order to clarify the complex global phenomena and the mechanisms behind them, and to maintain progress while sustaining a healthy environment, it is necessary to integrate the related science and technology and to promote the R&D. It is also necessary to conduct R&D based on a broad global perspective and a long-range view.

In the promotion of earth science and technology, it is necessary not only to deepen scientific knowledge regarding the earth, but also to promote close cooperation between the collection of scientific knowledge and the development of technology through endeavoring to progress with the development of techniques of observation, analysis and prediction for the purpose of obtaining scientific knowledge. Since there are also many areas which cannot be dealt with by individual countries, and those which require high scientific and technological standards, it is also necessary for countries to cooperate with each other. To meet international expectations,Japan also will have to undertake more dynamic international activities which suit its capabilities.

3.4.1.1.8.1 R&D and Related Measures for Understanding Global Phenomena

Global warming, ozone depletion, abnormal weather, earthquakes, volcanic eruptions and other global phenomena are closely linked to the social activities of human beings and pose the danger of exerting an enormous impact. For this reason, there is a strong need to understand these phenomena on a scientific level and make an appropriate response.

Table 3-4-8 Major research subjects in marine science and technology (in FY 1994)

Ministry or agency	Research institute or program	Subject
Science and Technology Agency	Special Coordination Funds for Promoting Science and Technoiogy	∗ International joint research concerning the elucidation of the substance circulation mechanismin the coastline sea ∗ Japanese ocean circulation experiment ∗ The Ridge Flux (International) Project
	Research and Development Bureau	∗ Kuroshio exploitation and utilization research
	Japan Marine Science and Technology Center	∗ R&D of a deep-sea research submersible ∗ Research on marine observation and R&D of observation technology ∗ Research and investigations into comprehensive observation of the North Pacific Ocean and Arctic sea areas
Environmental Agency	Research Funding to the National Research Institute engaged in Environmental Pollution Research	∗ Research concerning nitrogen cycle of deposits in inland bays
	Water Maintenance Bureau	∗ Research on red tide
	National Institute for Environmental Studies	∗ Research concerning the elucidation and maintenance of the ecosystem mechanism on the hydrosphere in a closed-type sea area
National Land Agency		∗ Surveys for the Promotion of the fisheries in the Amami Islands
Ministry of Education	National Universities and Other Research Institutions	∗ Ocean Drilling Program (ODP) ∗ Cooperative study of the Western Pacific (WESTPAC) ∗ International Cooperative Research Programme on Global Ocean Observing System (GOOS)
Ministry of Agriculture, Forestry and Fisheries	Fisheries Agency	∗ Devlopment of techniques for stock enhancement ∗ Devlopment of techniques for advanced use of fishing ground ∗ Reseach for improvement and development of fishing ground ∗ Observations of oceanographic environment related to fisheries ∗ Technological development of fishing implements and methods ∗ Administrative measures for marine environment conservation ∗ Research of marine space use ∗ Technological development of marine resources use
	Fisheries Agency Japan Marine Fisheries Resource Research Center	∗ R&D of fisheries resources
Ministry of International Trade and Industry	Metal Mining Agency of Japan	∗ Surveys for the development of deep-sea bottom mineral resources
	National Institute for Resource and Environment	∗ R&D into underwater manganese nodule mining systems
	Geological Survey of Japan	∗ Marine geological study of continental shelves in the eastern margin of the central Japan Sea
Ministry of Transport	Marine Technology Research Center	∗ Research concerning the development of next generational oceanic structures and evaluating their safety
	Ports and Harbor Technological Research Center	∗ Research on hydrophilic ports and harbors, and coastal structures
	Maritime Safety Agency Hydrographic Department,	∗ Cooperative study of the Western Pacific (WESTPAC) ∗ Researc on material diffusion at ocean depths
	Meteorological Research Institute	∗ Study of ocean general circulation with advanced numerical model
Ministry of Posts and Telecommunications	Communications Research Laboratory	∗ Research of global environment monitoring technology using airborne high-resolution topographic and polarimetric imaging radar
Ministry of Construction	Public Works Research Institute	∗ Study on beach stabilization and sorting of mixed grain sized sand ∗ Development of coastal environment conservation program in tropical zone
	Geographical Survey Institute	∗ Shema of coastal sea areas

Since problems such as global warming and crustal movement are long term and are not confined to a country, it is of crucial importance to maintain a sense of global partnership and cooperation in R&D in earth science and technology. Accordingly, it is important that Japan play an active role in the World Climate Research Program (WCRP), the International Geosphere-Biosphere Program (IGBP) and other joint research programs and expand joint research projects with research institutions abroad. In consideration of Japan's geographical position in the Asia-Pacific region and its close economic relationship with the countries of the region, there is a need for it to promote research and development that gives priority to this region.

In addition to using their budgets to conduct research and development aimed at explaining global phenomena, the ministries and agencies of the Japanese Government make use of special coordination Funds for Promoting Science and Technology, Funds for the Promotion of Surveys and Research in Earth Science and Technologies and Ocean Development, Funds for the Overall Promotion of Environmental Research in order to link a broad range of research capacities, including those of national research institutes, universities and overseas research organizations, and positively conduct research and development on a comprehensive and international level that is aimed at assessing the influence exerted on the global environment by human activity.

As an international effort to promote exchange of earth observation data such as satellite data and in-situ data on global changes, the Asia-Pacific Network for Global Change Research (APN) is a regional network that cooperates with relevant government ministries and agencies to actively promote research of global change. In order to conduct discussions aimed at the construction of a research network in the Asia Pacific region, a workshop was held in Tokyo in January 1994, and the establishment of two working groups was determined.

Furthermore, in March of this year, a workshop was held in Tokyo, at which discussions were conducted on APN-related topics, such as scientific themes and matters of organization and procedure, based on the reports by the Working Groups. As a result, a joint proclamation announcing the graduation of the APN from preparatory stage to operating stage was adopted.

For the purpose of achieving a clearer understanding of global phenomena, it is important to promote the international circulation of information from earth observation. Based on this understanding, Japan is actively participating the Global Observation Information Network (GOIN) established with the United States under the U.S.-Japan Comprehensive Economic Conference in April 1993. GOIN was established with the purpose of circulating and promoting the utilization of satellite and ground observation data in fields such as global change research, disaster and environmental monitoring. In particular, it aims for interconnectivity and interoperability for U.S.-Japan information systems. With the Science and Technology Agency as the co-chair of the Japanese side, U.S. and Japan organized Joint Program Working Group, and has been carrying on discussions in cooperation with the relevant U.S. and Japanese government ministries and agencies since September 1993. The results of these discussion were to be compiled in June of this year, and after a two-year transitional phase, the operational phase is scheduled to begin.

In addition, after the Naples Summit of July 1994, a cabinet-level conference for the Global Information Society was held in Brussels this February. At this conference, 11 subjects were adopted for pilot projects for the purpose of realizing the Global Information Society. One of these themes is "Environment and Natural Resources Management" and in this relation Japan is now actively taking steps toward advancing the wider circulation of earth observation information.

Table 3-4-9 Major research subjects in earth science and technology (in FY 1994)

Ministry or agency	Research institute or program	Subject
Science and Technology Agency	Special Coordination Funds for Promoting Science and Technology	∗ Japan-China joint study on desertification ∗ Japanese experimental study in the Arctic Area ∗ Studies for prediction of fundermental datasets for Earth science and technology research
	Funds for the Promotion of Surveys and Research in Earth Science and Technologies and Ocean Development	∗ An observational study of cloud effects for global warming ∗ Japanese study on the behavior of greenhouse gases and aerosols ∗ Research on the Asian monsoon mechanism ∗ Dynamic and predictability of El Nino Southern Oscillation (ENSO)
	National Research Institute for Earth Science and Disaster Prevention	∗ Studies on Mechanisms and impacts of climate change caused global warming
Environment Agency	Global Environment Research Program Fund	∗ Comprehensive observation and analysis of variability of the ozone layer ∗ Study on the carbon cycle in oceanic and terrestrial ecosystems ∗ Studies to Clarify the behavior of acidic and oxidative component of the atomosphere in East Asia ∗ Evaluation of material circulation and the biological uptake and accumulation of pollutants in marine ecosystems ∗ Analysis of the environment and structure of tropical forest ecosystem ∗ Evaluation of interaction between desertification and human activities ∗ Establishing an environmental accounting system (Green GNP) ∗ Fundamental relationship between population growth and environmental problems in developing countries
Ministry of Education	Universities, etc.	∗ Academic research into earthquake and volcanic eruption prediction systems ∗ Research on global environmental change with emphasis on the Asia and the Pacific region ∗ Arctic environment cooperative research project ∗ Solar terrestrial energy programme (STEP) ∗ International geosphere-biosphere programme (IGBP) ∗ Japan antarctic research ∗ A sientific Approach toward globalism human society in harmony with the earth: man-earth system
Ministry of International Trade and Industry	Geological Survey of Japan	∗ Geological, geochemical and geophysical research of active volcanoes ∗ Marine geological research concerning sea areas surrounding the continental shelf in the eastern edge of the central Japan Sea and other subjects
Ministry of Transport	Hydrographic Department, Marine Safety Agency	∗ General ocean surveys of sea areas under agency supervision, oceanographic surveys using earth observation satellites, surveys of ocean floor contours and subterranean structures for volcanic eruption prediction, survey of water temperature, currents and waves in the Western Pacific Ocean as part of the agency's sea lane supervisory activities ∗ Collection, supervision and supply of information on water temperature and the role of currents in ocean water circulation, and materials involved in ocean floor contours, geology and earth-related physics
	Meteorological Research Institute, Meteorological Agency	∗ Research concerning of global warming prediction technology ∗ Developing a prediction model for El Nino
Ministry of Posts and Telecommunications	Communications Research Laboratory	∗ International joint research on advanced electromagnetic technology for the global environment ∗ Research concerning binary frequency Doppler radar for observation of rainfall from space ∗ Research concerning measurement technology of the global environment by means of short-wave length electro-magnetic waves in mill-wave bandwidths ∗ R&D concerning measurement technology of the global environment with optical sphere active sensors ∗ R&D concerning measurement and information networks of the global environment ∗ Developing a space-based astrological forecasting systems
Ministry of Construction	Geographical Survey Institute	∗ Developing topographic survey system by synthetic-aperture radar
	Public Works Research Institute	∗ Research on methods for grasping water circulation by remote sensing

Table 3-4-9 summarizes the major research and development subjects in the area of earth science and technology that are currently promoted by related ministries and agencies.

3.4.1.1.8.2 R&D on Earth Observation Technology

R&D on earth observation technology is important to accumulate the information necessary to understand various global phenomena. For this purpose, in January 1993, Council for Aeronautics, Electronics and Other Advanced Technologies addressed Recommendation for Request No. 17 on Promotion Policy for Comprehensive Research on Earth Observation for the Resolution of Global Environmental Problems. Japan's two major thrusts in this area are the R&D on earth observation technology, including the R&D on earth observation using satellites, and the R&D on marine observation technology such as the development of deep-sea survey vessels.

(1) Earth Observation Technology Using Satellites

Earth observation using satellites is extremely effective for continuous acquisition of various information covering areas and currently, Japan is promoting a comprehensive project, cooperating with related organizations domestically and abroad.

The National Space Development Agency of Japan (NASDA) is operating earth observation satellites including the Marine Observation Satellite-1or "Momo 1" (MOS-1), "Momo 2" (MOS-lb) and the Japanese Earth Resources Satellite-1 or "Fuyo 1" (JERS-1), and is developing the Advanced Earth Observing Satellite (ADEOS), the Tropical Rainfall Measuring Mission (TRMM), and the Advanced Earth Observing Satellite (ADEOS-II) in cooperation with related organizations.

The Ministry of International Trade and Industry is promoting the development of the Advanced Spaceborne Thermal Emission and Reflection radiometer (ASTER) which is to be loaded on the first Polar Orbit Platform (EOS-AM1) of the United States National Aeronautics and Space Administration (NASA).

For establishing observation and data processing techniques of the global environment by using satellites, the Science and Technology Agency, in cooperation with related organizations, is encouraging Research on Earth Environment Remote-Sensing Technology.

The Science and Technology Agency is consolidating databases in preparation for the international networking of information that will allow the effective use of the above mentioned data obtained from earth observation satellites.

International cooperation is important for developing of equipment for performing observation using these earth observation satellites and for promoting of effective use of the ovservation data. Therefore, Japan played a pivotal role in vigorously participating in and contributing to various venues of international coordination, including the Committee on Earth Observation Satellites (CEOS) and the Polar Orbit Platform Coordination Working Group (EO-ICWG).

(2) Marine Observation Technology

Elucidation of the relationships between the oceans and the occurrence of natural phenomena is an important issue in our understanding of global change.

To further knowledge in this area, the Japan Marine Science and Technology Center is promoting several areas of R&D, including R&D on ocean acoustic tomography and started to prepare a large-sized ocean observation vessel.

3.4.1.2 Science and Technology for the Coexistence of Human Beings

With the expansion of human activities, issues caused by the finite of the earth such as global environmental issues are revealed. In order to solve these issues and provide new means which allow human beings to coexist in harmony with the earth, the *General Guideline for Science and Technology* established at the

Cabinet meeting in April 1992 positioned the following fields as science and technology for the coexistence of human beings.

- Preservation of the earth and natural environment
- Development and utilization of energies
- Development and recycling of resources
- Continuous production of foods

3.4.1.2.1 Preservation of the Earth and Natural Environment

In recent years, environmental issues on a global scale such as global warming are revealed, and it is urgent that these issues be solved through international cooperation. It is also important to prevent regional pollution and preserve the natural environment in order to improve a comfortable living environment. Therefore, it is necessary to promote R&D to respond to environmental issues on a global scale, prevent pollution, and preserve the natural environment.

The Council of Ministers for Global Environment, which maintain close communication with the related administrative agencies while promoting effective and all-around measures, was established for Japan to deal with environmental problems, which have a severe worldwide effect, and is currently working actively on these problems.

The Council of Ministers for Global Environment held in October 1989 (established in May 1989, dissolved in August 1993, re-established with the understanding of cabinet ministers in December 1993) reached agreement The Comprehensive Promotion of Research, Observation/Monitoring and Technological Development for the Conservation. Based on this agreement; a Comprehensive Promotion Program for Global Environmental Research, Monitoring and Technology Development is settled upon by the Council each year. The Council of October 1990 set goals for controls on emissions of Greenhouse Effect gases such as carbon dioxide in the Action Program Arrest Global Warming.

In November 1993, the Basic Environmental Law was promulgated and put into effect in order to take appropriate measures against today's environmental problems in this era of globalization. The legislation aims to promote science and technology and experimental research scheme in connection with environmental protection, and provides for: the promotion of R&D and the dissemination of results; taking steps toward the cultivation of research staff; and the securing of international cooperation regarding surveillance and observation in connection with protection of the earth's environment. In December 1994, a Basic Plan for the Environment was adopted (at Cabinet meeting on December 16, 1994). This is an overall government plan which sets down the fundamental principles behind comprehensive and long-term policies regarding preservation of the environment based on the Basic Environmental Law. The plan provides for international efforts and long-term goals, including the following:

- Realization of economic and social systems which exert little impact on the environment
- Co-existence of humans with nature and other animals
- Participation of all people in environmental preservation activities
- International efforts

There is also one clause provided for the promotion of technologies suited to the improvement of investigation, research, monitoring and observation. In particular, it stresses the need to promote the solution of problems with the earth's environment through accumulating sufficient scientific knowledge.

In addition, Commission on Global Environment in the 21st Century led by the Prime Minister (chaired by Jiro Kondo, chairman of the Central Council on the Environment) have been held 12 times since March 1994. On January 17, 1995, the group issued its report, "Toward the Creation of a New Civilization – Proposals by Commission on Global Environment in the 21st

Century" which outlines the establishment of an agency to create strategies for the environment; environmental education, learning and practices based on environmental ethics; and the formation of a citizens' council on the environment.

International efforts against global environmental problems include the June 1992 United Nations Conference on Environment and Development (UNCED:Global Summit) in Rio de Janeiro, Brazil. At the Summit, achievements such as the adoptions of the "Rio Declaration on Environment and Development", which contains the principles for action for countries and individuals, and the "Agenda 21" which is the action program to implements those principles, and the securing of signatures from many nations for the United Nations Framework Convention on Climate Change, were made. The "Rio Declaration on Environment and Development" proclaims that countries should work towards cooperation through the promotion of scientific understanding through the exchange of scientific and technological knowledge and technological development and transfer. Agenda 21 also mentions that science is indispensable to the proper control of the global environment, and points out the importance of: research toward understanding the earth, including human relations on it, as a system; improving scientific understanding through observations of the earth from space and research on oceanographic observation; reinforcement of the scientific base for the purpose of sustaining development; improvement of scientific methods for evaluating environmental change; and the cultivation of scientific capability in developing countries.

Based on Agenda 21, Japan submitted the Agenda 21 Action Program to the U.N. on December 28, 1993 (adopted on December 24, 1993 at the Council of Ministers for Global Environment). One of the 6 priority items cited in the action program is the securing and enforcement of international cooperation regarding observation, surveillance and research in connection with the protection of the global environment. Through the promotion of scientific study, research, observation and surveillance regarding complex earth systems, fundamental understanding will be deepened,along with promoting increased understanding of the mutual influence that human activities and the global environmental changes that come with them have on each other.

In accordance with the United Nations Framework Convention on Climate Change, which went into effect on March 21, 1994, Japan sent its report (the decision of the Council of Ministers for Gloval Environment on September 13, 1994) to the temporary office of the treaty. The contents of the report included policies and measures for the purpose of preventing global warming, such as lists of emission and absorption of Greenhouse Effect gases, scientific studies and research, and promotion of observation and surveillance. According to this report, in the year 2000, the amount of carbon dioxide emitted per person in Japan is expected to be roughly the same as it was in 1990, however, the overall amount of carbon dioxide emitted in the year 2000 is expected to be greater than that of 1990. The first conference of treaty member countries was held from March 28 to April 7, 1995. At these meetings, a decision was made to initiate the deliberation process to set clear regulations under the treaty for the as yet undetermined years from 2000 and beyond. This decision aims to make efforts for the year 2000 and beyond, including setting policies and steps to be taken, setting specific quantified restrictions and reduction targets for the years such as 2005, 2010 and 2020, and to start the discussion process as soon as possible, in order to reach a decision at the 3rd meeting of treaty member countries in 1997. These efforts are designed to strengthen the agreement through the adoption of a protocol or the like. In addition, actions such as the decisions to introduce the idea of joint implementation of global warming prevention measures on the part of several member countries and to establish a permanent secretariat, and the proposal by advanced nations of a

Climate Technology Initiative (CTI), represent steps taken toward full-scale implementation of the treaty.

Mankind is a member of the earth's ecosystem, and must coexist with other organisms. However, in light of the worsening of the habitats for other living things due to human activities, the extinction of species of wild animals is progressing at an unseen rapidity. Under these circumstances, in order to protect the various living things on the earth with their habitats, and to conduct sustainable utilization of biological resources, an international framework known as "Convention on Biological Diversity" was adopted. It was accepted by Japan in March 1993 (It was put into effect in December 1993, and has been signed by 106 countries as of December 1994). Active steps are being taking in Japan, mostly by the relevant government ministries and agencies, for the sake of protecting the biological diversity and achieving sustainable utilization of biological resources.

Japan is promoting R&D for the antipollution measures in a prioritized fashion through efforts such as the Prioritized Reinforcement and Comprehensive Promotion of Experimental Research for the Antipollution Measures (set each year by the Environment Agency). In recent years, there has been a particular interest in a new environmental restoration technique using the functions of microorganisms to decompose and concentrate harmful substances (bioremediation). The "Bioremediation" is expected as a new purification technology for pollutants which are difficult to be decomposed,such as trichloroethylene and PCB, in addition to those based on physical and chemical methods available until now. The relevant government ministries and agencies are currently conducting active R&D on the bioremediation.

Research topics for protection technologies for the global and natural environment to be executed in FY 1994 are collected in Table 3-4-10.

3.4.1.2.2 Development and Utilization of Energy

Overall R&D promotion in energy-related fields requires careful prioritization, planning and implementation because of the broad range of scientific disciplines involved and the substantial, long-term monetary and personnel investments required. For these reasons, the government has assumed the responsibility to coordinate R&D in energy-related fields.

In August 1978, *The Basic Plan for R&D on Energy* was established. Subsequently, several revisions were made based on changes in the energy situation, and in July 1991, the government adopted a new "Basic Plan for R&D on Energy". Since then, the plan has been steadily promoted. Revisions to the Basic Plan are currently being worked out, based on changes in the energy situation in recent years, such as the outlook for increasing worldwide demands on energy and the heightening of debate over global environmental issues.

3.4.1.2.2.1 R&D and Utilization of Nuclear Energy

In energy-related fields, nuclear energy facilities are capable of providing a steady supply of low-cost electricity without discharging harmful gases, such as carbon dioxide or nitrogen oxides, into the atmosphere in the process of generation. For this reason, the government is committed to promoting on-going R&D to strengthen the nation's energy infrastructure by making nuclear energy a primary source of supply. In addition, the use of radiation is being promoted in a wide range of fields, including medicine, agriculture, engineering and environmental preservation. Thus, the use of nuclear energy in Japan is closely related to the lifestyles of its people, and is contributing greatly to the stable securement of energy and the improvement of the quality of life of its citizens.

Table 3-4-10 Major research subjects on global / natural environmental conservation technology (in FY 1994)

Ministry or agency	Research institute or program	Subject
Science and Technology Agency	Institute of Physical and Chemical Research Japan Atomic Energy Research Institute	* Photosynthetic science * Development of smokeless radiation treatment
Environmental Agency	Global Enviroment Research Program Fund Research Funding to the National Research Institute engaged in Environmental Pollution Research Survey and Research Funds for the Nationl Organization for Pollution Prevention National Institute for Environmental Studies	* Joint development of technology for improving water quality to facilitate greater use of natural resources in developing countries * Joint research into health effects associated with and prevention of illness caused by atmospheric pollution due to coal burning in developing countries * Techniques for quantitatively evaluating exposure of harmful substances generated by industrial waste landfills * Ozone layer protection technology and associated evaluation * Overall assessment of strategies to prevent global warming * Studies of conservation on wet land biological diversity in tropical Asia * Genetic diversity of rare species of wild animals and associated conservation
Ministry of Health and Welfare	Subsidies for research welfare science	* Ecological health and effects of disease * Promoting healthy environment in terms of water supplies and waste treatment
Ministry of Agriculture, Forestry and Fisheries	National Institute of Agro-Environmental Sciences	* Managing the agro-, forest-, marine-ecosystems to control global change
	Subsidies for projects developing technology for regeneration of forests in tropical regions	* Projects developing technology for regeneration of forests in tropical regions
	Subsidies for projects contributing to food production technology	* Technology for environmentally-sensitive food packaging * Technology to encourage microorganism wastewater treatment in the food industry
	Consignment expenses	* Studies on the development of environmental restoration technology in agricultural and fishing industries utilizing functions of living organisms
Ministry of International Trade and Industry	New Sunshine Program	* Environmental technology * Denitration catalysts for exhaust gas from low-fuel burning engines

In order to advance the research, development and utilization of nuclear energy in Japan in a comprehensive and systematic way, the Atomic Energy Commission (AEC) formulated the Long-Term Program for Research, Development and Utilization of Nuclear Energy. This long-term program, which was revised for the seventh time in June 1994, clarifies the role of R&D on nuclear power, based on a long-term outlook with a view toward the 21st Century. Upon these revisions, through opinion gathering, Public Opinion Hearings, and a wide range of informal discussions among learned persons in fields other than those related to nuclear power, the program is drawing upon the opinions of not only domestic and international nuclear energy experts, but also those of citizens from all walks of life.

(1) Current State and future outlook of Nuclear Power Generation

As of March 1995, there were 48 commercial nuclear power plants in operation, with a total output capacity of 40.366 gigawatts. In FY1993, 31.2% of the nation's electrical power was supplied by these facilities.

The goals for the future scale of nuclear energy development, according to the Long-Term Program for Research, Development and Utilization of Nuclear Energy, are plant capacities of roughly 45.6 million kW by the year 2000, and 70.5 million kW by 2010. In addition,the proportion of nuclear power generated in the supply of electrical power is steadily increasing. In 2000, the percentage of commercial nuclear power generated in the overall generated energy is anticipated to be 33% and in 2010, 42%.

Japan has commercial nuclear power plants in 17 sites (48 plants). Important topics for the future are the expansion of existing sites and the establishment of new sites, as well as the finding of locations for nuclear fuel cycle facilities and related facilities.

Japan will promote nuclear power facilities by continuing activities to find locations through government, business and local public organizations, and regional promotion and active public relations through the mass media to promote understanding with the goal of attaining amicable co-existence between the area inhabitants and the nuclear power facilities.

Most nuclear power in Japan is currently generated using light water reactors. Here, the government, electric utility companies and manufacturers of atomic power generation equipment, etc. have cooperated to develop technology that enhances the level of reactor reliability, minimizes downtime and reduces employee exposure to radiation. But the current level of light-water reactor safety not being overrelied, the technology should be advanced with the aim of improving the economies, reliability and safety.

From the viewpoint of ensuring the independence and stability of Japan's development and utilization of nuclear energy, Japan will continue to make efforts toward securing the stability of natural uranium resources and conducting overseas investigations and mining.

PNC is actively promoting R&D of gas centrifuge uranium enrichment technology which can be used toprovide a stable supply of enriched uranium for the nation's power reactors. A commercial uranium enrichment plant at Rokkasho-mura in Aomori Prefecture, started partial operation in March 1992 on the basis of PNC's research results. R&D also has been conducted on new technologies including laser isotope separation that make uranium enrichment more economical, and on the like.

(2) Establishment of International Trust for Non-Proliferation

Although Japan's promotion of the use of nuclear power is limited toward strictly peaceful ends under its Atomic Energy Basic Law,it recognizes the need to make efforts to obtain international trust through the establishment of policies of nonproliferation and international cooperation regarding nuclear power. Strict implementation of the safeguards of the International Atomic Energy Agency (IAEA), based on the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), as well as nonproliferation measures based on the Bilateral Nuclear Cooperation Agreement, have become the basis of Japan's nuclear policy. Technological research of security measures are being conducted with an emphasis on safeguards for plutonium handling facilities in reprocessing plants and uranium enrichment facilities. In addition to its responsibility under the NPT structure, and while adhering strictly to the principle of non-possession of surplus plutonium, Japan realizes the importance of making efforts to assuring clarity under a rational and consistent program, an in addition to making public the management conditions of its plutonium, together with working towards a concrete international framework for the purpose of increasing the clarity of nuclear fuel recycling programs. While keeping in close contact with the relevant countries, Japan has also decided to carefully promote cooperation with countries with which it has not heretofore had cooperative relations regarding unclear fuel recycling. Furthermore, Japan is also actively promoting the development of technologies related to nonproliferation, and is conducting R&D for assurance of nuclear non-proliferation, such as the R&D of actinide recycling technology.

(3) Measures for Assuring Nuclear Safety

In Japan, from the beginning, the development and commercialization of nuclear energy have been conducted with priority to safety and the containment of radioactive materials.

To assure nuclear safety, stringent regulation is conducted by the government that is not observed in other industrial areas. The regulation includes the environmental radiation monitoring, emergency measures for accidents, etc.

To ensure even higher safety standards, the Nuclear Safety Commission establishes Annual

Nuclear Safety Research Program and evaluates the results of researches to promote safety research comprehensively and systematically.

In accordance with the Annual Nuclear Safety Research Plans (three annual safety research plans (1991-1995) dealing with nuclear energy facilities, environmental radioactivity, and high-level radioactive wastes established in 1990, and the annual safety research plan (1994-1998) for low-level radioactive wastes established in 1994), the following nuclear safety research activities are being promoted.

Regarding safety research for nuclear power plants, Japan is dealing with the expansion and diversity in nuclear power development and utilization such as the advances in light water reactors and the large scale expansion of nuclear fuel cycle work by conducting research in fields including the stochastic safety evaluation of such items as water reactors, high speed breeder reactors, nuclear fuel facilities, the transport of radioactive materials, the earthquake-resistance of nuclear power plants, and nuclear power facilities themselves. Research on the safe disposal of radioactive waste is also being conducted in accordance with the Radioactive Waste Disposal Plan. The above safety research is being conducted mainly by Japan Atomic Energy Research Institute, Power Reactor and Nuclear Fuel Development Corporation, and national testing and research organizations.

Furthermore, Japan is also conducting safety research related to environmental radioactivity through safety evaluation research in fields such as the environment, dosage quantities, biological effects, and internal exposure to specific nuclear species centering at the National Institute for Radiological Science.

In addition, discussions are currently underway for the purpose of setting three yearly programs (1996-2000) for research on nuclear power plants, radioactivity in the environment and high-level radioactive waste.

(4) Increasing Domestic and International Understanding and Providing Information

In order to promote the development and utilization of nuclear power smoothly, it is important first to gain a feelings of trust and security from the citizens towards the government and nuclear power organizations.

For this purpose, the best thing to do is to build up and establish a record of safety and nonproliferation. Japan is also making efforts towards the establishment of administration and management methods acceptable to the citizenry, through forums for exchange of opinions in which the citizens participate, and plans to provide timely and precise information that will be the foundation for citizens to make their own judgments.

Although certain information regarding protection from nuclear materials, non-proliferation, and protection of property rights should not be made public, in principle, information on these matters will be considered open to the public. In order to end criticism that only "positive" information is being selected to supply to the public, consideration in this vein will be boosted and information will be provided utilizing new media, such as information networks.

In light of the significant international interest in nuclear nonproliferation and safety, it is also important for Japan to gain international understanding and trust for the smooth promotion of this nuclear power development and utilization. For this purpose, it will be necessary for Japan to actively send overseas information regarding the peaceful utilization of nuclear power and safety securement.

(5) R&D on Nuclear Fuel Recycle

Japan, a country with scarce energy resources, is steadily carrying forward research and development effort aimed at commercial commissioning of nuclear fuel recycling, which makes recovered plutonium and uranium reusable as fuel through the reprocessing of spent fuel for the purpose of ensuring its future energy security. Nuclear fuel recycling is also effective in terms of preserving resources and the environment, and improving the treatment and disposal of radioactive waste. In order to establish a comprehensive technological system concerning the use of plutonium that will be needed in future age of fast breeder reactor, and to improve the long-term overall economic efficiency of nuclear fuel recycling, it will be important to carry out nuclear fuel recycling on a certain scale. Therefore, Japan will systematically promote a program with affection also being given to the fact of its playing a certain role in terms of supply of energy as well.

Utilization of MOX fuel will be started in a few pressurized water reactors (PWR's) and boiling water reactors (BWR's) in the second half of the nineties and be conducted in about 10 reactors by the year 2000, and ten odd by the year around 2010 in a planed fashion, allowing for flexibility. It is also important to enhance understanding and trust at home and abroad concerning utilization of MOX fuel through the construction and operation of advanced thermal reactors. Operation of the prototype reactor "Fugen", will be continued by Power Reactor and Nuclear Fuel Development Company (PNC) and the construction program of the No. 1 demonstration reactor is proceeded with the goal of starting operation soon after the year 2000 by an electric power company. Reprocessing of spent fuel will in principle be conducted at home, and along with operation of the Tokai reprocessing plant of PNC a private reprocessing plant (annual processing capacity of 800 tons) is already under construction and is scheduled to be commitioned shortly after 2000. Smooth progress in its construction and operation is expected to result in steady development of reprocessing technology on commercial scale.

Plutonium recovered in, overseas reprocessing will basically be used for fabrication of MOX fuel in Europe to be utilized in light water reactor in Japan. And considering operation of the Rokkasho reprocessing plant it will be necessary to establish commercial fabrication of MOX fuel in Japan as well on a scale of a little under 100 tons a year by shortly after the year 2000. In that connection an early decision will have to be made, chiefly by the electric power companies themselves, concerning what entity is to undertake such commercial fabrication of MOX fuel.

Since fast breeder reactors can produce more nuclear fuel than it consumes while generating electricity, it is considered that it will constitute the central element of the nuclear fuel recycling system in the future. Therefore, Japan intends to steadily and systematically carry forward development of fast breeder reactors with the aim of eventually making them the mainstream of its nuclear power generation after fairly long period in which it will be used along with light water reactors.

As for the prototype reactor "Monju" which reached its initial critically in April 1994, performance tests on it will be steadily carried forward. Based on the results obtained through its development, an electric power company will carry forward plans to start construction of the No. 1 demonstration reactor soon after the turn of the century. Aimed of the Researches on the reprocessing of spentfuel of fast reactors will be carried out, with the PNC playing the central role in them.

In addition, it is intended to carry forward long-term R&D efforts on advanced nuclear fuel recycling technologies which may be able to reduce impact on the environment and awares non-proliferation. Currently, efficient ways of its promotion is studied in Advisory Committee on Nuclear Fuel Recycling Program of the Atomic Energy Commission.

Furthermore, it is necessary to go about nuclear fuel recycling on the basis of the principle of not having plutonium beyond the amount required to implement the program, i.e. the principle of no surplus plutonium, as well as having very strict management of nuclear materials, and to work on the basis of rational and consistent plans and strive for transparency so as not to give rise to any international doubt concerning violation of non-proliferation of nuclear weapons.

(6) Nuclear energy back end measures

The most important remaining task for the sake of ensuring a consistent system of nuclear power generation is the establishment of ways of appropriately accomplishing treatment and disposal of radioactive waste and decommissioning of nuclear energy facility (backend measures).

As for low-level radioactive wastes, measures are taken to reduce their generation, and the generated wastes are submitted to proper volume reduction and solidification treatment.

Low level radioactive wastes have been disposed of at shallow land burial facility by a private company from December 1992.

High-level radioactive waste generated from the reprocessing plant is vitrified into a stable form, followed by storage for 30 to 50 years for cooling, after which it will be disposed of underground in a deep geological formation. This procedure is the government's basic policy on high-level radioactive waste from the reprocessing plant. In April 1995, the first return of High-Level radioactive waste (vitrified residue) to Japan was performed, with the remaining waste to be returned in the future. Construction of the waste management facility in Rokkasho-mura, Aomori Prefecture, was completed in January 1995, and commercial operation began in April of the same year. The project was approved by the Prime Minister in April 1992.

In addition, in May 1993, the Steering Committee on High-Level -Radioactive- Waste Project was inaugurated, and is now making preparations for the type of organization to perform the processing business and its foundation. On the other hand, R&D is being promoted on geological disposal by the PNC. As a part of these activities and to consolidate geological disposal technology, PNC also is planning to set up the Storage Engineering Center as an integrated research center for storing high-level radioactive waste and other materials.

Separation of nuclides contained in high-level radioactive waste, conversion of long-lived nuclides into short-lived, or non-radioactive nuclides, and transmutaion technology are important research themes. Basic R&D activities are carried out in a long-range viewpoint with the cooperation of the JAERI, PNC and other concerned organizations.

Since FY1981, the Japan Atomic Energy Research Institute has been tackling R&D on technological developments related to measures to abolish nuclear reactors from nuclear power facilities modeled on the Japan Power Demonstration Reactor (JPDR). The actual dismantling of JPDR has progressed from FY 1986. It was performed to decontaminate the floors and walls of reactor enclosure and to remove components in other building. Furthermore, extremely low level concrete wastes generated from the dismantling of JPDR are planning to be disposed of by simplified shallow disposal. In addition, the Nuclear Power Engineering Corporation (NUPEC) has been proceeding with a verification test for reactor abolishment technology since FY1981.

(7) Diversified Development of Nuclear Science and Technology and the Strengthening of Basic Research

Nuclear fusion is expected to become an inexhaustible source of energy for mankind, and active efforts are being made both domestically and internationally in the field of nuclear fusion. In Japan, R&D in nuclear fusion is being carried out in accordance with "The Third Phase Basic Program of Fusion Research and Development" adopted by the AEC in 1992. The main goals of this program are attaining self-ignition condition, realizing long burn and forming the basis of reactor engineering technology needed for development of a prototype fusion reactor. The International Thermonuclear Fusion Experimental Reactor (ITER) project, whose Engineering Design Activities (EDA) is now undertaken jointly by Japan, the U.S., the EU and Russia, could become the central apparatus used for R&D toward the above goals. In the New Long-Term Program (for Research, Development and Utilization of Nuclear Energy), it is expressed that Japan intends to participate in EDA of ITER in an active way.

Under the ITER program EAA (1992-1998) is now being conducted based on the results of the

Conceptual Design Activities (1988-1990). In EDA,Joint Central Team for the design has been established at sites in NaKa, Ibaragi Prefecture, San Diego (U.S.) and Garching (EU), which cooperates with each Home Teams of the four parties to advance the design and R&D on the related necessary engineering and physics. The teams are currently in a stage of full-scale design activities.

In addition to the R&D related to the ITER, the Japan Atomic Energy Research Institute (JAERI), universities and national research organizations are working together on R&D in nuclear fusion, and are also actively involved in international cooperation. JAERI, which has used the Break-even Plasma Test Device (JT-60) to record remarkable results and achieve the world's highest plasma performance, is also conducting R&D in reactor engineering technologies. The National Institute of Fusion Science (NIFS), which is an organization for cooperative use with universities, is advancing the construction of a Large Helical Device (LHD) which is scheduled to be brought into operation in FY1997. Other research is being conducted at universities and national research organizations, including basic research on various magnetic confinement systems and inertial confinement system, and research in reactor engineering technology.

As regards the utilization of radiation, the New Long-Term Program formulated their policies on the promotion and diffusion of the advanced R&D using accelerators.

Radiation has come to be used in a wide range of fields, beginning with the basic sciences and extending into medicine, agriculture and industry. In medical sciences, research is being conducted on the uses of protons, heavy ion beams or the like to treat malignant tumors, while diagnostic technology employing X-ray computer tomography and X-/ gamma-ray radiotherapy for malignant tumors already is widely utilized. In particular, the National Institute of Radiological Sciences (NIRS) is using heavy ion beams for the research into cancer treatment, and from June 1994, clinical trials on actual patients using radiation treatment were started. Researchers at Tsukuba University's Proton Medical Research Center, for example, are carrying out studies on the diagnosis and treatment of cancer using proton beams.

In agriculture, forestry and fisheries, radiation is being used for plant breeding, sterilization of vermin, and food irradiation, etc.

In industry, radiation is being used for non-destructive testing, for quality improvement of polymers, etc.

Since FY1986, JAERI has been constructing an Ion Irradiation Research Facility. Its completion is scheduled for 1993. It began partial operation in FY1991, then full-scale operation in FY1993.

JAERI and the Institute of Physical and Chemical Research (RIKEN) are advancing the maintenance of a synchrotron radiation facility in the Harima Science Garden City in Hyogo Prefecture. Its partial operation is scheduled for FY1997. The National Laboratory for High-Energy Pyisics of the Ministry of Education also has been conducting high-intensity synchrotron radiation research using the "TRISTAN" injection-accumulation ring.

A promising field for R&D in high-temperature engineering is the generation of energy using high-temperature gas reactors. Advances in this field hold the promise of opening up many possible alternative sources of energy. JAERI is now constructing a high-temperature engineering test reactor (HTTR) with the goal of establishing high-temperature gas reactor technology and pioneering basic research into high-temperature phenomena.

JAERI is leading R&D on the Mutsu nuclear-powered ship which in February 1991, began a year-long series of test voyages to obtain knowledge concerning the effects of vibration, pitching and rolling, and variation in load on the nuclear reactor in an oceanic environment, and all experiments were finished successfully in February 1992. During this period, there were four journeys offshore of the Hawaiian Islands to the east, the Fiji Islands to the south and the Kamchatka Peninsula to the south, to obtain worth-while data, on normal sea areas, high temperature sea areas and violent sea areas.

At present, Japan is promoting the removal and separation method in which the nuclear reactors is removed and dismounted from the ship's hull together with the nuclear reactor chamber, and is carrying out the construction of a reactor storage and display building. In addition, making full use of the results obtained from the Mutsu, research on design evaluation is being conducted.

In addition to the above programs, JAERI, the national universities and the national research institutes are furthering basic research in the following fields. In particular, the JAERI established a new Advanced Basic Research Center in April 1993 in order to further consolidate basic research activities.

- Nuclear and reactor physics
- The physiological effects of radiation
- Irradiation testing of fuel assemblies and materials

Also JAERI, PNC, RIKEN and the national research institutes are developing a number of underlying technologies in the following seven areas. Latter three areas were added in April 1994.

- Materials technology for nuclear facilities
- Artificial intelligence technology for nuclear facilities
- Laser technology for the nuclear energy field
- Technology for assessment and reduction of radiation risk

(8) Contribution to the World Community

To achieve international cooperation regarding nuclear power, it is necessary to promote development and utilization with the cooperation of an international society. In order to make clear the basic stance regarding policy questions such as the compatibility of nonproliferation and peaceful use of nuclear energy, it will be important to conduct bilateral and multilateral policy dialogue to a greater extent than has been conducted until now. Japan has been expressing its views by conducting policy talks during participation at regularly held conferences with other countries in addition to actively participating in forums such as international conferences. In view of its rise to attain a key position in the world through concentrating its efforts on development of technology, Japan is committed to active independent cooperation. Regarding questions of nuclear power safety in the former Soviet Union and Central and Eastern Europe, which is matter of worldwide concern, Japan is also implementing bilateral assistance such as improving safety through the installation of Leak detection system, using the microphone and improving the operators' ability through international seminar, and funding multilateral assistance program of Nuclear Account (NSA) of European Bank for Reconstruction and Development (EBRD), International Atomic Energy Agency (IAEA) and Nuclear Energy Agency (NEA), of the Organization for Economic Cooperation and Development (OECD).

3.4.1.2.2.2 R&D on Natural Energy

In order to ensure a stable supply of energy and cope with global environmental issues, it is necessary to promote R&D aimed at expanding the use of natural energies such as solar energy, geothermal energy, ocean energy and wind-power energy. Active R&D is being promoted by R&D Program on Energy and Environmental Technologies (The New Sunshine Program) and Japan Marine Science and Technology Center, among other organizations.

Solar energy is an inexhaustible energy source, and is also capable of playing an important role in dealing with global environmental issues. However its energy density is low, and changes in output occur depending on natural conditions. It will be necessary to advance R&D while taking into account the special characteristics of solar energy.

Solar energy can be utilized for feat supply, photovoltaic power generation and other needs. Technological development of solar water heater systems for residential use has been completed and the system is spreading among general households. R&D into technologies to promote the industrial use of solar energy are underway. The government also is encouraging R&D on photovoltaic power generation with the goal of substantially lowering the cost of solar batteries and their systems while improving their efficiency.

In addition to being a pure nationally produced energy containing an abundance of resources, geothermal energy also has the characteristic of being inexhaustible. It will be necessary to promote R&D aimed at expanding its utilization. For this purpose, Japan is promoting the development of technologies such as geothermal energy exploration techniques, excavation and extraction techniques, the development of binary-cycle power generation,and the development of elements technology of hot dry rock power generation.

R&D are progressing in the application of efficient wave energy utilization systems, ocean thermal energy conversion systems and others. R&D is also being furthered on combined systems that would integrate these, technologies with power generation by breakwaters and the use of deep-sea water.

Wind-power energy is a clean and renewable energy, but its energy density is low and its variations are large. Therefore it is important to aim for reductions in cost, secure long term stable operations, and systematize is order to make its use practical.

Wind-powered energy has already been introduced and widely used as a part of electric power supply sources in Europe and America. Japan is now promoting R&D into large-scale wind power generation systems with the goal of expanding the use of collective-type wind power generation systems and wind power energy.

Although energy technologies which use biomass energy and photosynthetic functions of organisms have many associated problems related to energy density, transport and storage, their burden on the environment is small, and they are expected to become renewable energy resources. Research is being advanced into the manufacture of hydrocarbons from plants which efficiently fixate carbon dioxide.

3.4.1.2.2.3 R&D on Fossil Energy

In general, substances known as fossil fuels — coal, petroleum, natural gas, oil shale and tar sand — are underground resources of ash hydrogenates. Since the industrial revolution, mankind has built today's high level civilization through the utilization of these fossil fuels. However, it is now becoming necessary to deal with the limitations on these resources and problems with the earth's environment. Therefore, it is necessary to actively promote the R&D of fossil fuel to cope with the predicted increase in worldwide demands on energy, and to secure a stable supply of energy, while keeping in mind the impact on the earth's environment.

Oil is Japan's principle source of energy and the government is encouraging R&D of technologies for oil development to offset the effect of deteriorating conditions in the petroleum industry, such as the diminishing capacities of new oil fields. In addition, R&D is being conducted concerning identification of deposit conditions and effective utilization of petroleum in the neighborhood of Japan.

Coal has an outstanding stability of supply, and along with nuclear energy is the top substitute energy for petroleum. However, since it has more difficult handling aspects than liquid fuels, R&D on technologies such as coal liquefaction and gasification is being promoted. These technologies aim to diversify the areas of utilization of coal and raise the efficiency of utilization, and are very important in creating a fuel substitute for petroleum. In addition, these technologies are effective in reducing the emissions of harmful material such as sulfur oxides, and fine dust.

Since coal has one of the highest emission volumes of carbon dioxide during combustion among fossil fuels, it will be necessary to consider global environmental issues while conducting innovative R&D in order to reduce the load of carbon dioxide on the environment so that the utilization of coal can be expanded smoothly. For this purpose, Japan is promoting the practical development of clean coal technologies centered around high-efficiency coal combustion technologies, and studies and research on more innovative clean coal technologies for the next generation.

Since natural gas emits less carbon dioxide during combustion than other fossil energies, and gives lower impacts to the environment, it is still important to promote R&D concerning exploitation and utilization of it as a significant energy source. For this purpose, Japan is conducting research regarding not only the studies concerning identification of deposit conditions and extraction of natural gas and also the studies concerning transformation of it into liquid fuel for expanding its application areas.

3.4.1.2.2.4 R&D for More Efficient Use of Energy

From the viewpoint of securing stable supply of energy, coping with global environmental issues, and the effective use of limited energy resources, it has become essential to bolster R&D for more efficient usage of energy at each stage from its supply to end use and promote R&D for the optimum usage of energy for society as a whole.

For this purpose, Japan is promoting R&D of each elemental technology, including R&D aimed at the improvement of the energy conversion efficiency of ceramic gas turbines and fuel cells which have high power generation efficiency and contribute to the promotion and expansion of co-generation, and R&D aimed at improving the efficiency at time of end use of energy in the sector as energy transport technology, which includes superconductor wires and superconductive electric power applied technology, which are expected to stabilize and increase the efficiency of electricity transmission systems, and in sectors as industry, household transportation, agriculture, forestry and fisheries.

In addition, in order to increase the efficiency of energy utilization, along with continuing R&D in each elemental technology, it will be necessary to promote R&D aimed at the establishment of a system which uses energy effectively.

Japan is promoting R&D on effective utilization techniques for unused energy such as the waste heat and river water that is disposed from factories and city buildings, and R&D on energy storage techniques such as a measure for load leveling of advanced batteries.

In addition, R&D is being promoted for: a co-generation system which can supply heat and electricity simultaneously; a graded heat utilization system in which heat is effectively utilized from high to low temperatures; a wide area energy utilization network system which efficiently recovers unused low temperature heat discharged from manufacturing areas such as factories and supplies heat of various temperatures to areas of high demand,answering the needs of the household sector; and international clean energy network using hydrogen conversion system which uses various kind of renewable energies such as hydropower, solar, geothermal and wind power, produces hydrogen, and after converting it into a form appropriate for transportation,transports and stores it for utilization in a wide range of fields,including as fuel for generation and transportation uses, and as gas for cities.

Table 3-4-11 summarizes the major research subjects in development and use of energy undertaken by government ministries and agencies in FY1994.

3.4.1.2.3 Development and Recycling of Resources

For the purpose of the effective utilization of natural resources such as mineral resources, it will be necessary to promote the R&D of management systems based on evaluations of investigations, extractions, processing, and amounts of resources, and to promote R&D with an aim toward recycling resources, such as recycle utilization, cyclical utilization of water resources, and the manufacturing of products which are easy to recycle.

Table 3-4-11 Major research subjects in development and use of energy (in FY 1994)

Ministry or agency	Research institute or program	Subject
Science and Technology Agency	Special Coordination Funds for Promoting Science and Technology	* Development of energy conversion materials via inclined structure formation
	Japan Marine Science and Technology Center	* Technology for harnessing the energy of the ocean (part of research and development into use of the sea)
Ministry of Agriculture, Forestry and Fisheries	Overall research and development	* Environmental conservation techniques for advanced treatment and uses of egesta from livestock animals
	Major research projects	* General research into development and use of techniques using functions of living organisms to create new areas of demand
Ministry of International Trade and Industry	Industrial Science and Technology Frontier Program	* Ecofactort (pioneering research project)
	General technology development program for energy and the environment	* Solar energy * Thermal energy * Coal-based energy * Hydrogen energy * General research into ocean energy and wind power generation systems * Power storage via distributed batteries * Power generation by fuel cells * Superconductor power applications * Ceramic gas turbines * Wide-area energy utilization networks * Pioneering and pure technology in the field of energy conservation
	Technological research and development in important areas	* Advanced combustion technology utilizing short-term micro-gravity environments * Streamlined combustion and other energy utilization systems

R&D on a manganese nodule search system for the purpose of pumping up sea water at 4,000 to 6,000 meters to mine manganese nodules which contain important non-mineral metal resources such as nickel, bronze, cobalt and manganese, and R&D on metal resource production technology for the next generation for the purpose of aiming at the construction of an energy-saving,low environmental burden, new metal resource recovery technology are being advanced by The Ministry of International Trade and Industry.

The Ministry of Agriculture, Forestry and Fisheries is promoting research from the standpoint of protecting the environment, regarding the establishment of advanced processing and utilization techniques for domestic excrement, and the development of agricultural systems which preserve the harmony of ecosystems through the improvement of material cycles such as that of nitrogen in soil. In addition, for the purpose of effective utilization of the waste materials generated in large quantities from the food manufacturing industry, technological development necessary for the separation, recovery, recycling and utilization of useful substances in waste material is being promoted through waste material recycling and utilization technology development projects in food manufacturing, and the development of recycling and utilization technologies for ligneous waste in order to effectively use ligneous resources is also being promoted. Furthermore, areas such as the development of controls on construction by-products and recycling and utilization technologies are being promoted at the Ministry of Construction.

Table 3-4-12 summarizes the major research subjects in development and recycling of resources in FY1994.

Table 3-4-12 Major research subjects in development and recycling of resources (in FY 1994)

Ministry or agency	Research institute or program	Subject
Science and Technology Agency	Special Coordination Funds for Promoting Science and Technology	* Technology of evaluation and design of ecologically sound materials
Ministry of Agriculture, Forestry and Fisheries	Major research project	* General research to elucidate the ecological order in the agricultural, forestry and fishery systems an develop optimal controls
	Subsidies for projects contributing to food production technology	* Projects to develop recycling technology for waste products in food manufacturing industry
	Comprehensive research and development	* Environmental conservation techniques for advanced treatment and uses of egesta from livestock animals
	Separate General Research	* Next-generation agricultural techniques based on advanced resource cycle, functioning in harmony with ecological systems
Ministry of International Trade and Industry	Industrial Science and Technology Frontier Program	* R&D into underwater manganese nodule mining sytems
	Geological Survey of Japan	* 3-D modeling techniques for resource evaluation
	New Sun Shine	* Fundamental technology of producing metal-based materials through regeneration in harmony with the environment * Promoting recycling of non-ferrous metals

3.4.1.2.4 Continuous Production of Foods

The stable securement of food is an important problem shared by every country in the world. In addition, against a backdrop of future growth of the world's population, international supply and demand of food is estimated to fluctuate towards scarcity. From this standpoint, it will be necessary to build a stable and lasting production system for food and other agricultural, forestry and fishing-related products through R&D on: developing technologies for propagating new varieties of plants and animals,raising the productivity and developing the facilities of farming and forestland, improving management technologies for cultivation and breeding, streamlining storage and distribution systems, the collection and preservation of gene resources, and the development of uses for unused or under-used resources.

For this purpose, the Ministry of Agriculture, Forestry and Fisheries is actively promoting: comprehensive R&D aimed at expanding the demand for agriculture, forestry and fishery products, improving productivity, and achieving high-quality production and distribution; the development of a cultivation system for high-grade breeds which will create the basic technology for a new plant and animal breeding and propagation system that applies the results of frontier bio-technology; and the development of basic technologies for the production of high-grade fertilizer that utilizes,among other things, high-grade bioreactors.

Table 3-4-13 summarizes the major subjects in R&D on continuous production of foods undertaken in FY1994.

Table 3-4-13 Major research subjects in R&D on conrinuous production of food (in FY 1994)

Ministry or agency	Research institute or program	Subject
Ministry of Agriculture, Forestry and Fisheries	Subsidies for biotechnology development projects in advanced technology in agriculture, forestry, fishery and food production	* Development of fundamental technologies for high-function fertilizer production * Development of early raising method for biodegradable varieties
	Comprehensive research and development	* New types of paddy crops to boost demand * Constant technology for enhancing quality and boosting productivity of wheat and other dry field and paddy crops * Basic techniques for high yield and stable production of dry field crops
	Separate general research	* Technology to supply high-quality fruit and vegetables through an elucidation of post-harvest physiology * Technology to heighten safety of agricultural produce using plant immunity and other functions of living organisms * Development of Techniques for the Evaluation and Application of Functions of Agricultural, Forest, and Fishery Products that Contribute toHealth
	Major research project	* General research to develop new agricultural, forestry and fishery techniques through the clarification and control of biological information * General research relating to the development of technology for the development and utilization of functions of living organisms to create new demand * General research to elucidate the ecological order in the agricultural, forestry and fishery system and develop optimal controls
	Specific research areas	* Technology to produce high quality milk alleviating environmental stress * Elucidation of regression characteristics of mid-migration fish and development of resource management technology
	Biotechnology development projects in cutting-edge technology	* General research in biotechological plant breeding
Ministry of International Trade and Industry	Industrial Science and Technology Frontier Program	* Technology for utilizing functions of tropical organisms

3.4.1.3 Science and Technology for Enriching Life and Society

Japanese society is maturing and the proportion of old people in the population increases and The Japanese are increasingly seeking mental or psychological fulfillment by leading comfortable, relaxed lifestyles. In this context, it is even more important than ever to maintain and improve health, secure safety and improve life environment and the socioeconomic foundation. With this understanding, the 18th Recommendation of the CST (submitted in January 1992) indicates the importance of encouraging science and technology for the enrichment of individual life and society, and the Japanese government established the *"Basic Policy for Science and Technology"* at the cabinet meeting in April 1992 in response to this recommendation. The related ministries and agencies are encouraging R&Dto maintain and improve the health, improve the life environment, the socioeconomic foundation and perfect disaster prevention and safety measures.

The importance of newly "considering the viewpoint of living people" is pointed out in the 1995 Important Guidelines for the Promotion of Science and Technology by the CST's policy committee. The Science and Technology Agency established the Basic Research Program for Life and Society in 1995, to promote science and technology which put a greater emphasis on the point of view of individual life.

3.4.1.3.1 Maintaining and Improving the Mental and Physical Health of the People

Maintaining and improving the mental and physical health of the people is the cornerstone to enabling everyone to live comfortable and prosperous lives.

For this purpose, it is important to encourage R&D on various technologies to maintain and improve physical and mental health on a dally basis, and R&D on technologies to prevent the generation of and for processing various materials harmful to human body, techniques for decreasing their influences on human body. It is also necessary to advance and integrate medical technologies by developing diagnosis and treatment methods and the medicines for diseases to be perfectly cured, and for diseases taken up as social issues. In this case, it is important to take into account the discussion concerning the dignity of men and bioethics from many aspects.

A number of government organizations have formulated policies and published recommendations that have established government priorities for R&D in health-related areas. Some of the key documents which have been drawn up include the following.

- *Opinions on Basic Guidelines for Promoting Cancer Research,* submitted in July 1983 by the CST
- *Opinions on Basic Guidelines for Promoting Neurological Science and Technology,* submitted in August 1987 by the CST
- *Opinions on Basic Guidelines for Promoting Immunological Science and Technology,* submitted in August 1987 by the CST
- *Guidelines for General Anti-AIDS Policies,* submitted in February 1987, revised in March 1992 by the Cabinet Council for AIDS-Counter Measures
- *Promotion of Basic Scientific Research for Formulating Drugs,* recommendation submitted in October 1990 by the Science Council of Japan
- *Promotion Plan for Comprehensive Research of Basic Formation for the Purpose of Advancing the Understanding of Brain and Nerve Functions,* submitted in June 1994 by the council for Aeronautics, Electronics and Other Advanced Technologies

Regarding cancer research, the findings of the Ten-year General Anti-cancer Strategy (adopted in June 1983 by the Cabinet Council on Cancer Countermeasures) which was completed in 1993, included the discovery of cancer genes and clarification of cancer-causing mechanisms by viruses, and the development of anticancer drugs. Japan recognizes the need to advance both clinical and preventive application of new understanding of the essence of cancer based on existing and future research finding. In FY1994, a new Ten-Year General Anti-Cancer Strategy was inaugurated. Under this new strategy, the relevant government ministries and agencies are undertaking R&D programs in the following areas: ① improve records of cancer treatment, ② encourage medical care that considers the position of patients and their families, and ③ disseminate information related to cancer on a nationwide level. Specifically, it will aim to promote such measures as: the elucidation of cancer-spreading mechanisms, the establishment of accurate diagnosis methods using genes, the establishment of new treatment methods such as a cancer treatment apparatus which utilizes heavy corpuscular rays, and the development of ultramodern diagnosis instruments which incorporate advances in computer technology and other areas. In addition, regarding the serious ailment to the immunity system that is AIDS, the Guidelines for General Anti-AIDS Policies was submitted in 1987 by the Cabinet Council for AIDS-Counter Measures. Revisions were introduced in March 1992, and research is being promoted based on the same guidelines, at the Science and Technology Agency, the Ministry of Education, and the Ministry of Public Welfare.

In addition, Japan is now facing a population aging with a speed unprecedented anywhere else in the world. To deal with this situation, based on the Guidelines for Countermeasures for the Aging of the Population submitted by the Cabinet in 1986, and the Opinions on Basic Guidelines for Promoting Science and Technology Appropriate to Long-lived Populations (submitted in 1986 by the CST), the relevant government agencies and ministries are promoting R&D on problems such as the aging of the population through measures which include a ten-year program for the promotion of scientific research on longevity conducting by the Ministry of Health and Welfare.

Other R&D in this field being conducted at the Science and Technology Agency, the Ministry of Health and Welfare, The Ministry of Education, the Ministry of Agriculture, Forests and Fisheries includes such subjects as: solving the causes of, establishing preventive and treatment methods for, and developing pharmaceuticals for illnesses which are difficult to cure, such as circulatory ailments; the understanding and the development of diagnosis and treatment methods for the mechanisms which set off mental and physical disorders; diagnostic medical instruments using ultramodern technology; the development of pharmaceuticals, an area in which private industry has been lagging behind due to poor marketability; and the discovery and preventive treatment of the mechanisms that cause food allergies.

Table 3-4-14 summarizes the major research subjects in maintaining and improving the mental and physical health of people undertaken by various government ministries and agencies in FY 1994.

3.4.1.3.2 Improvement of the Life Environment

Dealing with issues such as improving the quality of life, the proportional increase of old people in population structure and making adjustments to the decline in the birthrate, are, to some extent, the responsibilities of the local community, the family and the individual. However science and technology are expected to contribute much to deal with these problems by taking proper measures.

Therefore, it is important to promote R&D on the life technologies of food, clothing, housing, etc., and the technologies to give a mental satisfaction and to support the formation of communities in order to create an affluent life environment which allows men to exhibit their characteristics and a cultural life. It is also important to encourage R&D on welfare technologies to delicately meet diverse needs so that the old, the handicapped can live without feeling largely inconvenience and actively participate in social activities.

The CST has addressed these issues and set out R&D priorities in *Opinions on Basic Guidelines for Promoting Science and Technology Appropriate to Long-lived Populations,* submitted to the Prime Minister in May 1986. Based on this, the government is encouraging R&D in areas related to lifestyle improvement, support for various cultural activities, the fostering of safe, livable communities and adjustment to a prolonged demographic shift toward an aging population.

In this regard, the Science and Technology Agency, the Ministry of Health and Welfare, the Ministry of Agriculture, Forestry and Fisheries, the Ministry of International Trade and Industry, the Ministry of Transport and the Ministry of Labor are encouraging R&D in the following areas: the development of technology applied to measuring the human senses, which will contribute to the development of high-grade products and high-grade living spaces; study and research in connection with the establishment of safety measures to cope with the changes in the traffic environment in recent years,such as ultra-high ships; R&D into the technology for developing all areas of medical welfare equipment including that designed for the needs of the elderly; R&D into living assistance systems designed to meet the needs of people with mental and physical disorders; R&D into the construction and effective utilization of lifestyle information systems for the health preservation and medical treatment required by an aging society.

Table 3-4-15 summarizes the major research subjects in the area of improvement of the life environment undertaken by various government ministries and agencies in FY1994.

Table 3-4-14 Major research subjects in maintaining and improving the mental and physical health of people (in FY 1994)

Ministry or agency	Research institute or program	Subject
Science and Technology Agency	National Institute of Radiological Sciences	* Project research on medical use of accelerated heavy ions
	Institute of Physical and Chemical Research	* Function of cancer-related genes
	Research Development Corporation of Japan	* Development of laser cancer treatment and other commissioned development projects
	National universities (through provision of grants-in-aid for science research and other funding)	* Development of the basic technology to analyze mechanisms of cancer invasion and metastais * Reseach on the development of fundamental technics for controlling HIV infection and expression * Research on development of basic technology for molecular design and efficient systhesis of bioregulotors
Ministry of Education	National universities (through provision of grant-in aid for scientific research and other funding)	* Research on five important areas about cancers, Comprehensive coordination of cancer research, etc * Survey and research on cancer in foreign countries
Ministry of Health and Welfare	Grent-in-aid for scientific research in health and Welfare areas	* Research in priority areas identified in Second Term Comprehensive 10-Year Strategy for Cancer Control * Studies and research into AIDS prevention, treatment and pharmaceuticals development * Longevity science — understanding aging and dementia
	Subsidies for scientific testing research funding	* Studies and research on special illnesses
	National Institute of Health Nutrition	* Biochemistry of exercise and diet with respect to prevention of adult diseases
	National Cancer Center	* Understanding the causes of cancer and its prevention, diagnosis and treatment
	National Cardiovascular Center	* Prevention and diagnostic treatment of illnesses in circulatory organs
	National Center of Neurology and Psychiatry	* Understanding the causes of illnesses in mental state, nerves and muscles, and establishing methods of treatment and preventative strategies
Ministry of Agriculture, Forestry and Fisheries	Separate General Research	* Development of Techiques for the Evaluation and Application of Functions of Agricultural, Forest and Fishery Products that Contribute to Health
	Major research project	* General research into development and use of techniques using function of living organisms to create
Ministry of International Trade and Industry	Industrial Science and Technology Frontier Program	* Stereotactic Treatment System for Cancer * Optical Tomographic Imaging System

3.4.1.3.3 Improvement of Socioeconomic Foundation

The improvement of a social and economic foundation is being sought domestically and abroad as society as a whole advances and becomes complicated through progressive urbanization and the development of traffic, transport and telecommunication systems. Therefore, it is important to encourage the following.

- Technologies for comprehensive utilization of national land
- Technologies for civil engineering and construction of public facilities
- R&D concerning traffic and transportation
- Technologies aimed at the establishment of an advanced information communication system
- Technologies for the construction of a data base
- R&D of waste treatment technologies

Furthermore, with attention to the decrease of load on the environment, it is also important to promote R&D on the technologies concerning production activities to respond to the diversification of consumer demands and the shortage of labor force.

Table 3-4-15 Major research subjects in the area of improvement of the life environment (in FY 1994)

Ministry or agency	Research institute or program	Subject
National Police Agency	National Research Institute of Police Science	* General development of substance detection technology for scientific investigation
Science and Technology Agency	Special Coordination Funds for Promoting Science and Techology	* Development and effective utilization of everyday information systems to support health and health care in an aged society * Studying ways to revitalize secluded place in the mountains
Ministry of Agriculture, Forestry and Fisheries	Separate General Research	* Studying ways to revitalize secluded place in the mountains
Ministry of Health and Welfare	Subsidies for research welfare science	* Logevity science-development of supporting equipment for at-home care * Public amenities in residential areas
Ministry of International Trade and Industry	Industrial Science and Technology Frontier Program	* Development of measuement and application technology on human senses * Load regulating auxiliary walking devices * Next-generation aural device engineering * Independent egesta support systems * Comprehensive support for wheelchair users * Technology in product evaluation and advanced measurement fields
Ministry of Transport	Research and Development on Transportation Technology	* Establishing comprehensive safety strategies consistent with recent changes in transport conditions * Research and Development on Accessibility of Public Transportation for the Erderly and the Handicapped
Ministry of Labor	Comprehensive Research and Development	* Developing machines to help expand the scope of work available to the elderly and enhance safety and health

A number of government organizations have formulated policies and published recommendations that establish priorities for furthering R&D in these areas. Some of these documents are as follows.

- *Vision for R&D on Construction Technologies for the 21st Century,* published in July 1994 by the Ministry of Construction.
- *Basic R&D Programs at the Ministry of Transport,* published annually by the Ministry of Transport.
- *Research and Development Guidelines for Telecommunications Technology,* published in May 1992, partly revised in August 1993, by the Ministry of Posts and Telecommunications.
- *Transportation Technology Policy Prospect for the 21st Century* published in June 1991 by the Council for Transportation Technology.
- *Emphasis on Priorities and the General Promotion of Experimental Research Related to Pollution Prevention,* published annually by the Environment Agency.

Specifically, R&D into the technology for the development of deep underground spaces; technology for the maintenance, extension and improvement of the capacity of social capital; and R&D into comprehensive land utilization and construction technologies based on a model of conservation of resources and energy are being promoted by the Ministry of International Trade and Industry, the Ministry of Construction and other agencies. In addition, R&D into the development of advanced traffic and transport systems such as a superconducting magnetic levitated ground transportation system and a promotion system for a supersonic transport is being promoted by the Ministry of International Trade and Industry, the Ministry of Transportation and other agencies. Furthermore, the Ministry of Posts and Telecommunications and other agencies are promoting R&D into the development of advanced information and communication systems, including R&D into effective technologies for the utilization of radio waves.

Table 3-4-16 Major research subjects in the area of improvement of socioeconomic foundation (in FY 1994)

Ministry or agency	Research institute or program	Subject
Science and Technology Agency	National Aerospace Laboratory	* Developing revolutionary ideas in aerospace transport * Structural safety of aging aircraft
Ministry of Agriculture, Forestry and Fisheries	Special Research	* Underground searching technology associated with development of central agricultural facilities
Ministry of International Trade and Industry	Industrial Science and Technology Frontier Program	* Development of very deep underground areas * Promotion of supersonic transporters * Production and Utilization Technology for complex Carbohydrates
	Mechanical Engineering Laboratory	* Technology to boost efficiency of aircraft
Ministry of Transport	Research and Development on Transportation Technology	* Low-polluting distribution using on-rail trailers
	Ship Research Institute	* Structural safety evaluation associated with weight reduction of ships
	Electronic Navigation Research Institute	* Upgrading functionality of aircraft anti-collision systems
	Traffic Safety and Nuisance Research Institute	* Noise assessment guidelines for applications such as upgrading capacity of conventional railways
	Grants-in-aid for research on railroad technology funding	* Technology for superconductor magnetic levitation railways * Railway-related technology
	Grants-in-aid for advanced research on ship technology funding	* Cost of research and development into next-generation vessels
Ministry of Posts and Telecommunications	Communications Research Laboratory	* Technology of using intelligent radio waves
Ministry of Construction	Comprehensive Technological Development Project	* New building technology in the construction industry * Energy- and resource-saving construction technology for national land * Technology of infrastructure maintenance, renewal and improvement * Technology for reducing and recycling construction byproducts
	Public Works Research Institute	* Advanced treatment facilities tailored to the introduction of disposers
	Building Research Institute	* New methods of providing residential housing in major metropolitan areas
	Geographical Survey Institue	* Development of techniques for preparing digital cartograhic information with topological structure

Table 3-4-16 summarizes the major research subjects in the area of improvement of socioeconomic foundation undertaken in FY1994.

3.4.1.3.4 Substantialization of Disaster Preventive and Safety Measures

3.4.1.3.4.1 Science and Technology for Disaster Prevention

Japan has experienced many natural disasters in its history, and as a result of implementing various disaster prevention measures has been able to achieve some level of success in alleviating damage and preventing its escalation. However, the Great Hanshin-Awaji Earthquake of January 17, 1995, caused the death of more than 5,500 and great damage to property. The damage caused by natural disasters remains considerable. In order to protect human life and property, and to continue to lighten the damage, it is necessary for the entire nation to continue making efforts towards achieving a greater level of disaster prevention, in addition to working out living habits which will build up stronger resistance to disasters. In order to take more effective steps towards these kinds of disaster prevention methods, it is important to take precautionary measures, prevent the escalation of damage in the event of a disaster, and utilize the available scientific and technological knowledge to its fullest during the disaster recovery, which is a stepwise process.

R&D into disaster prevention has the goal of establishing a scientific and technological system to realize effective measures for protecting human life and property from disasters, and from now on, while answering the demands of actual disaster prevention, there will also be a need to promote R&D in connection with disaster prevention in an organized and systematic fashion. Accordingly, the Basic Plan on R&D Concerning Disaster Prevention (determined by the Prime Minister in July 1981, revised in December 1993) was established to clarify the R&D goals which Japan should be pursuing as a nation, while keeping in mind changes in the social environment and advances in science and technology with a long-range view that looks ten years into the future. Japan's disaster prevention R&D is based on this basic plan, in which 5 points are indicated:

- To combine the strengths of researchers in many fields, and based on actual uses of R&D findings, to promote R&D comprehensively from a wide range of standpoints.
- To substantialize basic research and to advance solutions to natural phenomena which cause disasters and other mechanisms which set off disasters, together with promoting a wide range of R&D into flexible methods for dealing with a variety of disasters and types of damage.
- It will be important to devise comprehensive measures to deal with not only direct primary damage but also secondary and indirect damage (comprehensive disaster prevention).
- To promote R&D into not only disaster prevention functions that work in times of abnormalities, but also into those that also keep in mind harmony with the surrounding environment.
- To promote international contributions and cooperation.

Furthermore, special efforts within the field of R&D in connection with disaster prevention include observation and research which is being promoted in line with the aims of the 7th Earthquake Prediction Plan recommended by the Geodesy Council in July 1993 and the revision of the 7th Earthquake Prediction Plan recommended in April 1995. The related government agencies are working in close cooperation with national universities, through the Earthquake Prediction Promotion Headquarters (the headquarters chief is the Director-General of the Science and Technology Agency). In addition, observation and research is also being promoted in line with the 5th Volcano Eruption Prediction Plan submitted by the Geodesy Council in July 1993.

In order to lessen the damage of future earthquakes, it is crucial that Japan gather all its wisdom to build on and strengthen its observation and research related to earthquakes and aim to maintain the system. Regarding the earthquake prediction system, the Earthquake Prediction Advancement Headquarters has decided to strengthen observation and research, and to build on its effective overall advancement system.

Scientific and technological research into disaster prevention at each government ministry and agency is shown in Table 3-4-17. The contents of research are wide-ranging, and include earthquake prediction, earthquake disaster prevention, volcano eruption prediction, snow and ice disaster countermeasures, meteorological and water disaster countermeasures and earth-science and technology. There are also a considerable number of items in areas that make full use of frontier science and technology, such as technologies for space development and ocean development. In addition, in response to the Sanriku Haruka Off-Shore Earthquake (December 28, 1994) and the Great Hanshin-Awaji Earthquake (January 17, 1995), emergency research was initiated using the FY 1994 Special Coordination Funds for Promoting Science and Technology. The relevant government ministries and agencies are promoting the maintenance of facilities along with investigations, observations and research related to earthquakes, for example, at the Agency of Industrial Science and Technology's Geological Survey of Japan, including the Science and Technology Agency's National Research Institute for Disaster Prevention's promotion of the maintenance of wide area Deep Borehole observatories such as the construction of the deep borehole earthquake observatories of 3,000m in order to reinforce observation systems in metropolitan areas.

Table 3-4-17 Major research subjects in disaster prevention science and technology (in FY 1994)

Ministry or agency	Research institute or program	Subject
Hokkaido Development Agency	Civil Engineering Research Institute	* Study of road traffic information system for safety and amenity of winter traffic
Science and Technology Agency	Special Coordination Funds for Promoting Science and Technology	* Research on the sophistication of technologies for the prediction of earthquakes beneath the metropolitan area * Research on earthquake potential assesment around margin of Japan Sea * International cooperative research on the development of the prediction method for the disaster caused by sediment movement in volcanic regions
	National Research Institute for Earth Science and Disaster Prevention	* Research on crustal activities in the Kanto-Tokai area * Fundamental Reearch on Earthquakes and Earth's Interior Anomaly * Research on prediction of volcanic eruption * Researches on natural science and technology of snow disaster prevention related to living conditions * Study on the development of regional prediction method and utilization of regional warning systems of snowstorm * A study of disaster predictions in global hydrological processes and other projects * Elucidation of mechanism of slope disaster
Ministry of Education	Universities, etc.	* Basic research on natural disasters * Basic research for earthquake prediction * Basic research on other disasters (e.g. volcanic eruption prediction research)
Ministry of Agriculture, Forestry and Fisheries	National Research Institute of Agricultural Engineering Forestry and Forest Products Research Institute National Research Institute of Fisheries and Engineering	* Development of soil engineering and engineering geology for land improvement structure * Understanding the water and soil conservation functions of forests and improving technology in forest work * Study on development and improvement of technology for construction of fishing port
Ministry of International Trade and Industry	Geological Survey of Japan	* Study of erthquake potential in active faults * Study of process of active volcanoes and eruption activity
Ministry of Transport	Hydro-graphic Department, Maritime Safety Agency	* Surveys of submarine topography and geological structures
	Meteorological Research Institute, Meteorological Agency	* Study of stress field in the southern Kanto region and prediction of earthquake activity * Research into condition of weather, land, water and other elements
	Port and Harbor Research Institute	* Study on highly rational seismic design method of water front facilities against big earthquakes near great cities
Ministry of Posts and Telecommunications	Communications Research Laboratory	* Development of precise positioning using cosmic radio wave
Ministry of Construction	Comprehensive Technological Development Project	* Development of earthquake prevention technology in large urban areas * Development of disaster prevention systems on sediment disaster
	Public Works Research Institute	* Study on active control system for wind resistant design * U.S.-Japan cooperative research program on hybrid control of seismic response of bridge structures
	Building Research Institute	* The U.S.-Japan joint seismic research program utilizing large-scale testing facilities
Ministry of Home Affairs	Fire Defense Agency	* Study on regionality of long-period ground motion

Regarding international cooperation, technical cooperation is carried out through the acceptance of trainees and the dispatching of specialists under the Japanese International Cooperation Agency (JICA). Training courses executed in 1994 included Disaster Prevention Technology, in which disaster prevention techniques in areas including meteorological disasters, earth and sand disasters, and earthquake disaster prevention are instructed. In addition, training was also given in earthquake engineering, volcanology and preventive engineering against volcanic gravel and meteorology.

Other cooperative international efforts are being made within the frameworks of organizations such as the U.S.-Japan Committee on the Use of Natural Resources (technology for the prediction of earthquakes, wind-resistant / eathquake-proof structure), the United Nation's Economic and Social Committee for the Asia-Pacific Region (ESCAP) and the World Meteorological Organization (WMO) Typhoon Committee.

Furthermore, in 1989, a joint resolution by Japan and other countries calling for an International Decade for Natural Disaster Reduction (IDNDR) was adopted at the 44th General Assembly of the United Nations, and was initiated in 1990 with the goal of alleviating human suffering, material losses and public confusion due to natural disasters through cooperative international efforts. In May 1989, Japan organized its own IDNDR Promotion Headquarters under the leadership of the Prime Minister, and the basic guidelines for its operation were formulated in November of the same year. In line with the IDNDR goals, a workshop on earthquake prediction and alleviation of earthquake damage was held in March 1994. In addition, in May 1994 the U.N. hosted a worldwide IDNDR Conference (United Nations Disaster Reduction Worldwide Conference) in Yokohama. As host country, Japan undertook active cooperation by submitting the activity program for the future, "Yokohama Strategy," and giving financial assistance.

3.4.1.3.4.2 Labor Hygiene and Safety

Apart from R&D into the natural phenomena which cause disasters and the secondary disasters which generally accompany them, it is important to promote R&D into technology to combat fires and disasters caused by dangerous substances and R&D into technology for the operation, maintenance and management of very large structures and systems.

It is also necessary to promote R&D into technology which can cope with new dangers which are currently proliferating in people's everyday lives and in the work environment as the result of advances made in technology and information systems.

This R&D into technology for fire and dangerous substance disaster countermeasures and the securing of labor hygiene and safety is currently being promoted by the Ministry of International Trade and Industry, the Ministry of Labor, the Ministry of Construction, the Ministry of Home Affairs and other agencies. Table 3-4-18 summarized the major research subjects which have been carried out by ministries and agencies concerned in FY1994.

Table 3-4-18 Major research subjects in labor hygiene and safety area (in FY 1994)

Ministry or agency	Research institute or program	Subject
Ministry of International Trade and Industry	National Institute for Resource and Environment	* Dealing with dust in closed industrial working environments
	National Institute of Materials and Chemical Research	* Understanding the singular explosive potential of inorganic industrial gases and developing prevention technology
Ministry of Labor	Research Institute of Industrial Safety	* New inspection technology for hoist tools * Making new materials explosion-and flame-proof using static electricity
	National Institute of Industrial Health	* Measuring and evaluating transient state vibration in humans * Techniques for evaluating collection efficiency against particle diameter in filters designed to remove harmful particle substances
Ministry of Construction	Comprehensive Technological Development Project	* Technology for evaluating flame-proof and flame-resistant performance
Ministry of Home Affairs	Fire Defense Agency	* Automating and reducing the weight of fire-fighting equipment to enable greater mobility in fire-fighting activities * Techniques for evaluating fire extinguishing performance and poisonous nature of substitute halon * Advanced fire-proofing technology for residential fires * Research into the special characteristics of fires in underground facilities * Systems for assessing the properties of fire and encouraging evacuation

3.4.2 Research Activities by Organization

3.4.2.1 Research Activities at the National Research Institutes

The national research institutes conduct specific research activities under the auspices of the ministry or agency with which they are affiliated. In FY1995, expenditures by the national research institutes for experimental research costs, personnel costs and facility costs were 405.8 billion yen up 7.6% from the previous year. Table 3-4-19 lists these expenditures by ministry and agency. A total of 14,388 people were employed including 9,545 researchers. This was down 84 from the previous year, including 33 fewer researchers.

3.4.2.1.1 Ordinary Research and Special Research

Ordinary research consists principally of research activities in comparatively basic fields that is conducted on a regular basis to provide the foundation for other research activities.

Special research, unlike ordinary research, consists of planned research activities that must be conducted expeditiously within a fixed time period to meet social or governmental requirements.

3.4.2.1.2 Guidelines for Promoting Basic Research at Research Institutes

Looking forward to the 21st century, Japan is committed to promoting creativity in science and technology and especially in basic research for the betterment of society at home and abroad.

For the promotion of basic research the national institute are highly expected as well as universities.

In this context, a number of highly promising basic research projects are currently underway at the national research institutes, national universities, etc. Since this basic research provides the impetus for development of innovative technologies, the Science and Technology Agency utilizes the Special Coordination Funds for Promoting Science and Technology in the following ways to support R&D in national research institutes in accordance with the directives of the CST:

Table 3-4-19 Breakdown of expenditures for national research Institutes by ministry of agency

(million yen)

Ministry or agency	1994	1995
National Police Agency	1,358	1,435
Hokkaido Development Agency	164	164
Defense Agency	139,616	153,292
Economic Planning Agency	986	991
Science and Technology Agency	46,490	51,780
Environment Agency	9,389	10,200
Ministry of Justice	1,353	1,433
Ministry of Finance	2,652	2,526
Ministry of Education	10,316	11,600
Ministry of Health and Welfare	20,420	21,027
Ministry of Agriculture, Forestry and Fisheries	68,523	71,124
Ministry of International Trade and Industry	47,645	49,266
Ministry of Transport	10,195	10,371
Ministry of Posts and Telecommunications	8,255	10,099
Ministry of Labor	2,044	2,495
Ministry of Construction	7,115	7,305
Ministry of Home Affair	692	727
Total	377,213	405,835

Notes: 1. Since amounts have been rounded, the sum of the amounts for each column and the totals shown above do not necessarily agree.
2. Amounts include expenditures for the humanities.

- Enocouragement of Basic Research at national research institutes is to create seeds for innovative technologies at national resarch institutes. (Since FY 1985)
- Basic Research Core System is operated to promote fundamental research in national research institutes by gathering researchers inter-ministerially and internationally to one national research institute and enabling researchers to give full scope to their trailblazing studies. (Since FY 1988)
- System for Establishment and Support of Center's of Excellence (COE) is operated to support for establishing COEs by using effectively SCF. (Since FY 1993)
- Research Information Improvement/Inter-Ministry Network Promotion System is to promote; improvement and utilization of inter-ministry information network which connects resarch institutes of each ministries ; survey and research contribute to establishment of a data base on basic and fundamental data (since 1994)
- Cooperative System for Supporting Priority Research is to support researchers by providing them with technitians in accordance with their research details and needs. (Since FY 1995)

In FY1990, the science and technology special researcher system was established and implemented for activities in national research institutes by accepting young researchers in these institutes as part-time employees.

3.4.2.2 Research Activities at Public Research Corporations

In addition to the national research institutes, important government-sponsored research activities are conducted at public research corporations. Funding for these corporations is provided by government investments and subsidies as well as by private sector investment. They are effective measures for research since they allow for flexible management, are able to recruit researchers from a wide range of government and private-sector organizations and can finance their activities with investments from the private sector.

Public research corporations are destined to play an important role in Japanese R&D as they are capable of sustaining the comprehensive efforts required to accommodate the growing volume of large-scale, complex projects.

Table 3-4-20 lists the main purposes and research activities provided by the principal public research corporations.

Table 3-4-20 Public research corporations

Organization	Purpose and activities
Japan Atomic Energy Research Institute (JAERI)	To carry out comprehensive, efficient research on nuclear energy development; conduct basic and applied research on nuclear energy; nuclear reactor design, construction and operation; R&D of nuclear-powered ships; and to disseminate information and technologies.
Institute of Physical and Chemical Research (RIKEN)	To develop original, innovative technologies, conduct broad-ranging, advanced experimental basic and applied research level in physics. chemistry, agricultural science, biology and other fields; to disseminate information and technologies to the academic and industrial sectors.
Research Development Corporation of Japan (JRDC)	To commission development of new technologies, and basic research deemed necessary to develop new technologies, to disseminate information and technologies; grant concessions for the development of new technologies; promote communication among the international research community; facilitate technology transfer; Supply information pertinent to the international research community.
Power Reactor and Nuclear Fuel Development Corporation (PNC)	Primary development work is to establish key elements of the nuclear fuel cycle, including fuel development, uranium prospecting and mining, reprocessing of spent fuel, development of autonomous technology for fast breeder reactors, and new types of conversion reactors.
National Space Development Agency of Japan (NASDA)	To contribute to space science and technology and the utilization of the space environment for peaceful purposes, conduct general development of satellites and the launch vehicles to launch them, and to manage launching and tracking operations.
Japan Marine Science and Technology Center (JAMSTEC)	To further science and technology useful in ocean development; conduct general experimental research, including R&D of technologies for deep-sea surveys, R&D of technologies for Ocean observation; to commission and manage large, joint-use facilities for experimental research, conduct training programs, information gathering and dissemination.
Institute of Agricultural Machinery/Bio-oriented Technology Research Advancement Institution	To carry out R & D needed to pursue urgently and planned about agricultural technology adapted to the change of international agricultural environment with utelizing private sector, and to carry out experiment and research of development of new agricultural machines.
New Energy and Industrial Technology Development Organizations (NEDO)	To improve Japan's industrial technologies and to further international exchange in the field of industrial technology; conduct R&D of technologies for industrial use; establish a research infrastructure; promote joint international research.
Telecommunications Advancement Organization	To carry out leading-edge R&D works as a bridge to link basic research and applications in telecommunication areas, which is vital to economic and social growth, but the risks and costs are so high and the R&D period is so long that less attractive to the private sector.

3.4.2.3 Research Activities at Academic Institutions

Academic institutions conduct research with the goal of extending knowledge. At these institutions, innovation and creativity are fostered in an environment that encourages independence, inquisitiveness and the free dissemination of ideas.

Japan's national and private universities and colleges lie at the center of this activity and are charged with maintaining and raising the standard of the nation's academic worth. The universities and colleges promote academic development by paying high regard to the independence of researchers and encouraging education and research to mature together in studies that are focused around the humanities, social sciences and natural sciences.

The Ministry of Education supports research activities in graduate schools, departments of universities and colleges, their attached laboratories and research institutes and in inter-university research institutes. Although education and research activities are basically treated as two parts of an inseparable whole, for accounting purposes, expenditures designated for research can be classified into the following categories.

- Expenditures for ordinary research
- Expenditures for separately accountable research granted on the basis of research content and need
- Expenditures for research on specific projects
- Expenditures for installment and maintenance of research facilities and equipment

Expenditures for ordinary research to provide the foundation to conduct research independently, consist, at the national universities and colleges, of personnel expenses, research expenses by faculty members and research-related travel expenses by faculty members. The Ministry of Education supports personnel expenses and overall education and research costs for private universities and colleges through subsidies for working expenditures, expenditure for education / research equipment.

There are a number of expenditures allocated to cover the cost of special research, one of which is the Ministry of Education's Grant-in-aid for Scientific Research to promote advanced scientific research in fields that contribute to the furtherance of the sciences in Japan. This grant-in-aid covers the cost of independently planned research projects by a researcher or group of researchers affiliated with an academic institution which are deemed to be in the national interest for the furtherance of academic knowledge and for which outstanding results may be obtained. This grant-in-aid has been instrumental in furthering scientific research in Japan by encouraging creative and innovative scientific research and by nurturing the formation of distinguished research groups.

In FY1994, the following researches are being promoted.

- ”High-Priority Research” for promoting innovative research in areas which Japan is competing on a cutting-edge level in international community
- ”Priority Research” for promoting research in areas with strong scientific and social demands
- ”General Research (A), (B), (C)” for encouraging creative and innovative basic research and for developing social sciences and humanities
- ”Commendatory Research (A)” to promote research by capable young researchers
- ”Fellowship for encouraging special researchers”
- ”Experimental Research” for promoting both experimental and applied research
- ”International Scientific Research” for promoting international joint research projects
- ”Research Reporting Expenditures”
- ”Original Basic Research Expenditures” for promoting new scientific programs (Table 3-4-21).

Table 3-4-21 Research classifications for scientific research grants

Research classification	Purpose/Description
High-priority research	Promotion of pioneering scientific research in international leading-edge fields: 42 research themes are being promoted during FY 1992.
Priority research	Dynamic, intensive promotion of scientific research in areas or fields where strong scientific and social demands exist: Research projects for FY 1994 cover 83 different fields including environment, earth and space science, energy science, substance and material science, information and electronic science, cancer research life sciences, and social sciences and humanities as well as a special cancer-related research.
General research, commendatory research A, etc.	Support for research aimed at strengthening the foundations and maintaining or improving the level of scientific research and research conducted by university and other young researchers.
Experimental research	Greater promotion of experimental or applied research projects with the potential for research results to find commercial use as well as promoting social interaction with the private sector.
International scientific research	Promotion of foreign academic studies and joint research
Commendatory research B	Support for scientific research being conducted by elementary school, middle school, high school, and other school teachers and by private sector researchers.
Special researcher grants	Support for research conducted by special researchers of the Japan Science Promotion Association.
Research publishing promotion expenditures	Promote the publishing of scientific research results
Original basic research expenditures	Promote research themes decided based on opinion of the Science Committee (Promotion of research according to the new program format)
Grant-in-aid for COE research	Helping create a center for prominent research

In addition, in FY1995, Grant-in-Aid for COE Research was established to help create a center for prominent research.

Training and securing a large number of creative young researchers who can flexibly respond to developments in new research is also an issue of critical importance in strengthening the infrastructure for scientific research and for its development. In FY1985, the Ministry of Education addressed this issue by establishing the "Special Researcher Fellowship Program," a full-fellowship program under the auspices of the Japan Society for the Promotion of Science (JSPS). The program enables students to attend the later period of doctor degree programs in graduate schools and those who have obtained the doctorate degree to devote themselves to independent creative research. In FY1994 the amount of the fellowship fund was greatly increased so that the total of research fellows was expanded to 2,100.

In addition, scientific investigators at universities have been besieged with requests by private industry and other sectors of society. To address this, the Ministry of Education has implemented a number of measures that enable them to cooperate with private industry on joint research projects that meet the needs of society in an appropriate manner, while protecting the autonomy of the universities.

In FY1983, the Ministry of Education established the "University-Private-Sector Joint Research Program" to allow national universities and other institutions to accept researchers and research funding from private industry. These researchers collaborate equally with university researchers on joint research projects of common interest.

Researchers, both at universities and in the private sector, have expressed strong interest in this program. As of FY1993, 1,392 joint projects had been conducted under this program for the development of materials, equipment, civil engineering, architecture and other technology. From FY1987, the Ministry has commissioned "Joint Research Centers" at national universities for joint research projects and other areas of academic and private-sector cooperation. The

Ministry also is promoting private-industry and university cooperation on joint research by making it easier for colleges and universities to undertake contract research and accept contract researchers. Funds for this are provided through the Grant-in-Aid for Scientific Research. The Japan Society for the Promotion of Science also is encouraging academic-private sector cooperative activities through its General Liaison Committee.

Academic research is an all-encompassing intellectual endeavor that helps further knowledge regarding ourselves and our universe. Thus, expanding the frontiers of academic research requires cooperation and a free exchange of ideas across national boundaries. Over the last few years, the need for international effort to deal with resource and energy problems and global environmental problems has intensified. Moreover, many fields of scientific research, such as high-energy physics and nuclear fusion, require large-scale facilities and advanced equipment that are often beyond the capital resources of any single nation.

To address these issues, Japan is encouraging international cooperation in scientific research in the following areas.

- Invitation of researchers from overseas to conduct research in Japan under the Special Overseas Researcher Fellowship Program of Japan Society for the Promotion of Science
- Dispatch of Japanese researchers to participate in R&D activities overseas
- Encouragement of joint bilateral and multilateral research projects

Japan is involved in large-scale, international joint research projects under various agreements, both at the international and inter-organization levels. Research activities also are conducted under multilateral agreements with the International Council of Scientific Union (ICSU), the United Nations Educational, Scientific and Cultural Organization (UNESCO) and other international bodies. The Japan Society for the Promotion of Science also is actively encouraging university exchange programs with developing countries by the base university method.

The Ministry of Education is working on various measures to strengthen Japan's basic research, to complete preparations for the condition and structure to accept foreign researchers in order to encourage these kinds of international scientific exchanges.

In addition, in response to the increasing necessity and importance of international exchanges in academic research in recent years, the Science Council submitted its proposal entitled, On the Promotion of International Scientific Exchanges (Report) in July 1994. The document calls for:

1) The maintenance of a domestic research base which meets advanced international standards
2) The maintenance of a substantial system for accepting foreign researchers
3) The promotion of two-way international academic exchanges in which Japan is also a contributor

Based on the above, the Ministry of Education is actively developing concrete policies for promoting:

1) The maintenance and fortification of an international academic exchange system at universities
2) The maintenance and fulfillment of projects by the Japan Society for the Promotion of Science
3) Appropriate efforts towards large scale international research enterprises
4) International exchanges of academic information

In July 1992, a recommendation was given by the Science Council of Japan regarding "Comprehensive Promotion Measures for Academic Research in Prospect of the 21st Century" to respond to significant changes in the various situations surrounding academic research in recent years. In this recommendation, the basic concept for promoting academic research is proposed as follows.

1) Academic research as an intellectual and creative activity worth to all over the world
2) Consolidation of the research infrastructure with paying attention to academic research trends
3) Respect for the independence of researchers and demand for their social contributions
4) Comprehensive promotion of research and education

Based on this report and others, the Ministry of Education aims to elevate the level of Japan's fundamental scientific research to an international standard. In order to strive for a systematic and prioritized scientific research system that is open to the world, Japan is actively advancing comprehensive policies which include the substantialization of research funding, the reinforcing of research facilities and equipment at universities, establishing the Centers of Excellence (COE), the cultivation and securement of young researchers, and the prioritized promotion of basic research.

In April 1995, the Science Council submitted a proposal on the promotion of global environmental science which included the establishment of a central research agency for the purpose of furthering comprehensive and interdisciplinary global environmental science.

3.4.3 Strengthening the Infrastructure for Science and Technology Promotion

A strong promotional infrastructure is necessary for the smooth and efficient progress of research activities which meet needs inside and outside of Japan. The government is addressing this issue through its active implementation of the following measures:

- Investment in R&D
- Nurturing of research personnel and improvement of their treatment
- Management and supply of equipment and facilities, materials and genetic resources
- Promotion of research exchanges
- Dissemination of science and technology information
- Promotion of regional science and technology

3.4.3.1 R&D Expenditures

In FY1993, R&D expenditures for the public sector invested 2,600 billion yen on R&D, up 10.9% over the previous year. The money was spent primarily in areas deemed to be of national importance, such as conducting basic research, encouraging large-scale research projects and improving the infrastructure of R&D. Given this record, a continued increase in R&D investments by the government is desired.

R&D investment in the private sector had been steadily growing. However, in FY 1993 the figure was ¥10.0 trillion, a decrease of 4.9% from the previous year.

Based on current trends, private sector investments in R&D are expected to rise. In light of this, the government is making it more attractive for the private sector to increase investments through the implementation of the following tax measures and programs.

- *Tax Deductions on Experimental and Research Expense Increments*
- Exemptions under *The Tax Program for Promoting R&D of Basic Technologies*
- *Cooperative Development for Industrial Technology* for the development and commercial application of new technologies
- Credit guarantee programs

3.4.3.2 Nurturing of Research Personnel and Improvement of Their Treatment in Science and Technology

The cultivation and securement of scientific and technological personnel is crucial to stepping up the progress of science and technology.

In recent years, a decrease in the population of people having children has accompanied a decreasing birth rate and the aging of the population. In addition, concern over a decreasing interest in science and technology among young people has been pointed out. Thus, the outlook for the future of the securement of scientific and technological human resources is not one of optimism.

Under such conditions, the Prime Minister submitted to the CST in December, 1992, Inquiry No. 20, Basic Policy for Securing Human Resources in the Fields of Science and Technology. The CST accordingly conducted discussions and investigations into concrete policies for solving the various problems associated with the securement of human resources. In December 1994, a response was sent to the Prime Minister, who determined the Basic Policy based on this response. The contents of the report are as follows:

①Building a Social Environment in Which People can Feel Close to Science and Technology

To create a foundation for turning out large numbers of young people who will have the desire to take on the responsibility for the science and technology of the next generation, it will be necessary to build a social environment in which the people are concerned about and interested in science and technology, search for answers on their own, and try to be involved actively. Important policies include the following:

- to promote the establishment and fortification of museums for the natural and technological sciences in order to provide various opportunities for people to get close to and to understand and think about science and technology
- to increase the opportunities for young children and students to interact with nature as well as with researchers and technicians, in order to cultivate a creative desire to search for scientific knowledge in the classroom.

②The Establishment of an R&D Environment in which Researchers Can Tap Their Creativity

Science and engineering education can be made more attractive by assuring diversity and flexibility. The following efforts are important in order to create an attractive environment which educates researchers and technicians so that they can tap their full potential and continue growing:

- recognizing the increasing importance of education in science and engineering fields at higher educational organizations, to aim at strengthening higher education through improving the educational research funding and facilities and equipment at universities and graduate schools.
- recognizing the importance of fostering adaptability and creativity, to aim at securing human resources in R&D areas through offering a great variety of research opportunities to young researchers.
- recognizing that the development of innovative tools and methods is indispensable to solving problems based on the creative ideas of researchers, to aim at securing technicians who will assist research through working toward the organization of research assistance departments.
- in order to develop high value-added products that only Japan can produce, and recognizing the importance of encouraging emotional expression and creativity as well as advanced knowledge and technology, to aim at securing human resources in the area of production through the realization of a work environment which assures the adaptability of ideas and opportunities for development of personal ability.

③Encouraging the Participation of a Diversity of Human Resources in Science and Technology Activities

The participation in science and technology activities of a diversity of human resources, including women, older researchers and technicians who possess vast knowledge, and outstanding foreign researchers and technicians who come from different cultural backgrounds, will be encouraged, and the conditions and environment necessary for positively tapping their potential will be maintained. For this purpose, the following will be important:

- to increase opportunities for women to become active in these fields
- to increase opportunities for outstanding older researchers and technicians who are still enthusiastic about their work
- the appointments of foreign researchers and technicians who possess outstanding ability

The Ministry of Education established a Post Doctoral Fellowship Program in 1985 as a new project for the Japan Society for the Promotion of Science, to provide assistance to creative and outstanding young researchers. In addition, the Ministry is working to foster researchers through strengthening the maintenance of institutions of higher education such as graduate schools, and improving educational guidance. Furthermore, in order to arouse interest in science and engineering among young people, the Ministry has devised measures for FY1995 which include the introduction of participatory visits to universities and other institutions of higher learning and the establishment of a scientific volunteer system.

In addition, the Science and Technology Agency (STA) has implemented programs designed to raise the quality of work done by researchers and to stimulate research work at the national research institutes through study-exchange activities both at home and abroad. In FY1989, the STA supplemented these programs by establishing the Special Researcher Program for the Basic Sciences at the Institute of Physical and Chemical Research where capable young researchers could engage in self-initiated, independent research, and in FY 1990 by inaugurating the National Institute Post Doctoral Fellowship Program (activities transferred to the Research Development Corporation of Japan in FY 1993), which makes efforts to cultivate human resources by accepting young researchers with abundant creativity at national testing and research organizations.

In 1995, the Agency set up a new Priority Research Assistance and Cooperation Member System, which provides apt research assistance, including allowances to those cooperating in research, which matches the contents of research and meets the needs of researchers.

STA has recognized that good treatment of research personnel is a prerequisite for retaining capable researchers and for allowing them to reach their full potential. Since 1961, STA has coordinated the opinions of the various ministries and agencies and has made an annual request to the National Personnel Authority regarding the employment conditions of government researchers.

The first measure for FY1994, stated the desirability of revising the salary scales for research workers in view of the actual state of the salary scales for researchers in private institutions (especially those of newly appointed researchers and young researchers from the viewpoint of securing talented staff) to bring them into line with The Salary Scale 1 for Teaching Staff (applicable to tenured staff at national universities and other institutions), which itself has been specially upgraded to keep in step with the salaries being paid to teachers at compulsory education schools as part of the policy on securing human resources.

The second measure stated the desirability of improving the salaries of researchers assigned to Tsukuba Science City.

As a result of these requests, the starting salaries of researchers with bachelor is degrees were improved by 1.4%, those with master's degrees by 1.5%, and those with doctoral degrees by 1.5%. Also, the National Personnel Authority recommended that the rates should be made higher than the average raises awarded to middle-leading researchers. The average salaries of young researchers (research staff grade 2) and teaching staff grade 2 on The Salary Scale1 were revised by 1.5% each.

3.4.3.3 Management and Supply of Equipment and Facilities, Materials and Genetic Resources

In accordance with The Basic Directives for Consolidating the Infrastructure for Science and Technology Promotion, approved by the Prime Minister in January 1990, the various ministries and agencies are promoting measures to implement the following:

- Establishment of a system to ensure a more complete system of supply for the materials and genetic resources used in research
- Replacement of obsolete and outdated equipment and facilities at national universities and the national research institutes
- Development of the world's most advanced equipment and consolidation of core research functions
- Creation of favorable work environments at national universities and at national research institutes to conduct more joint research projects with outside researchers

In the area of biological research materials and genetic resources, the Institute of Physical and Chemical Research (RIKEN) has established a gene bank program for the collection, storage and distribution of the animal and plant cell cultures and genes required for research in the life sciences. Other RIKEN programs include the development of an information system for experimental data in the biological sciences, the development of test animals, and the collection, storage and apportionment of microorganism strains.

The Ministry of Education is setting up animal testing facilities as a part of the overall reorganization of its research support infrastructure at the national universities.

The Ministry of Health and Welfare is operating a Research Resources Bank that collects, stores and distributes human and animal cell cultures needed for the cancer research carried out under the 10-year comprehensive anti-cancer strategy.

The Ministry of Agriculture, Forestry and Fisheries is promoting the operation of the MAFF Gene Bank, which collects and stores genetic resources from all types of agricultural, forestry and fishery resources, including plants and trees, animals, marine life and microorganisms. The gene bank also supplies genetic resources and information in stock to researchers.

In addition, in FY 1994, operations began at a DNA bank which collects,accumulates and offers DNA and DNA information obtained from study results at the gene level such as genome research.

The Ministry of International Trade and Industry at its National Institute of Bioscience and Human-Technology Patented Microorganism Depository of the Agency of Industrial Science and Technology, deposits and distributes microorganisms related to patent research as well as conducts research on preservation technologies for use with plant and animal cells.

As one of its projects for improving research and development infrastructure, the Science and Technology Agency is constructing the Next-Generation Synchrotron Radiation Facility "SPring-8". RIKEN and the Japan Atomic Energy Research Institute (JAERI) are jointly implementing the enterprise. It will be the largest synchrotron radiation facility in the world with 8GeV stored electron energy. It also will perform as a source with higher brilliance and harder X-rays than conventional synchrotron radiation facilities. This facility can be used for research carried out in a wide range of science and technology fields, including materials science, electronics and life sciences. It will be a joint use facility opened to researchers both at home and abroad. In the U.S.A. and Europe construction projects of synchrotron radiation facility hava been undertaken, too. ESRF (European Synchrotron Radiation Facility) have been utilized since September 1994.

This SPring-8 is a R&D infrastructure facility vital for promoting basic and creative R&D, and is expected not only to help further basic research in Japan, but also to play a key role in international research cooperation.

R&D activities and manufacturing of instruments are to be continued as in 1992, and construction of the facility is being done at the Harima Science Garden City, Hyogo Prefecture. It is scheduled to be completed and ready for use in 1997.

This facility has been targeted as one of the facilities for COE research using synchrotron radiation, and in its role as a facility open to researchers both from Japan and overseas, it will be important to utilize the facility at the maximum of its capacity. For this purpose, the Law Regarding the Promotion of Common Use of Synchrotron Radiation Facilities was enacted at the 129th session of the Diet. This law is targeted at the promotion of shared usage, through the establishment of a system in which in principle the first consideration is the user, through the introduction of a designated corporation system (Organization for the promotion of Synchrotron Radiation Research) to uniformly handle relations among users, including the gathering and selection of ways to use the pertinent facilities and technical assistance. Based on Article 11 of the law, in October 1994, Japan Synchrotron Radiation Research Institute (JASRI) was defined as the Organization for the Promotion of Synchrotron Radiation Research to encourage common use of Sring-8. In a similar vein, the High-Energy Physics Research Institute (KEK) of the Ministry of Education, one of the core organizations in the field of accelerator physics, is carrying out research at the highly advanced synchrotron radiation facility using the "TRISTRAN" injection accumulation ring in order to become the first in the world to break into new fields of research.

In addition, the Ministry of Education is furthering the development world class state-of-the-art equipment, including the construction of the Large-Optical-Infrared Telescope (National Astronomical Observatory), the construction of Water Cerenkov Detector (Institute for Cosmic Ray Research, University of Tokyo), and a KEKB-Factory Project (National Laboratory for High energy Physics).

Based on the Act for Construction of R&D Structures concerning Industrial Technologies, the Ministry of International Trade and Industry, under the Research Foundation Construction Project, is constructing those research facilities which are necessary for sophisticated R&D that should be promoted in this country in the future but which are difficult to construct only by the efforts of the private sector. In this project, a third-sector enterprise, to be established with investment from the New Energy Comprehensive Research and Organization for the Comprehensive Development of Industrial Technology will construct and operate the facilities which are to be provided for common use to researchers both at home and abroad.

3.4.3.4 Promotion of Research Exchange

In recent years, scientific R&D have become increasingly advanced, complex and interdisciplinary in nature. To promote creativity in science and technology, Japan must commit itself to developing the organizational infrastructure for R&D that will allow for the free movement of researchers, as well as for dissemination of research findings and materials. This will ensure that the limited resources that can be made available for research are used as efficiently and effectively as possible.

In the past, the legal restrictions placed on civil servants and the strict asset control measures applied by the government made it difficult for researchers to interact and cooperate with the private sector, or other countries. The government has moved to remove impediments in the relevant laws by enacting *The Law for Facilitating Governmental Research Exchange* in November 1986. In March 1987, the cabinet approved *The Fundamental Policy for the administration of institutions to promote governmental research exchange between industry, universities and foreign countries* to help ease the implementation of the aforementioned law.

As to The Law for Facilitating Governmental Research Exchange there is a greater need for Japan to make international contributions in science and technology and strong domestic and foreign demands for it to promote basic and creative research. Under these circumstances, this law was amended in July 1992 to further relax the various restrictions surrounding Japan's research activities of national research institutes (Table 3-4-22).

Table 3-4-22 Summary of the law for facilitating governmental research exchange

Item	Legal system before enforcement of this law	Special measures under this law
Term adoption as public research officials (Article 3)	Within the National Civil Servant Law, it is a general rule that employment is based on a lifetime system and no period of employment is set.	* According to the guidelines determined by the National Personnel Authority based on the National Civil Servant Law, it became possible to establish a period of employment for research civil servants.
Appointment of foreigners as public research officials (Article 4)	In principle, foreigners can be appointed as researchers, but their work is limited to testing and research.	* Foreigners can be appointed even as research division managers or research section managers.
Participation in research meetings (Article 5)	As part of official duties (business trips, outside duties) or on holidays.	* One can be released from the obligation to carry out one's duties.
Exceptions to the law of Retirement Allowances for Government Officials concerning public research officials (Article 6)	For leave to devote oneself to research at a school, institute, hospital and other public facilities (research leave), half of the period is used for calculating the retirement allowance according to the length of service.	* For leave necessary for carrying out research entrusted, by or joint research with, a national research institute, 100% of the period is credited.
Transfer of patent rights, etc. relating to the results of government-commissioned research (Article 7)	National research institutes apply for patents, etc.	* Part of the patent rights can be assigned to a trustee who has borne the cost.
Use of patented inventions, etc. relating to international joint research conducted by the government (Article 8)	It is often requested to use patents, etc. of national institutes free of charge or at low cost in case of international joint research. To realize this, some legal basis should exist.	* For joint research with public organizations of foreign countries or international organizations conducted by the national government, it was arranged so that patents and other rights held by the national government related to these results can be used at no cost or minimal cost.
Handling of patent rights, etc. relating to the results of international joint research commissioned by the government (Article 9)	For consignments from the national government, patent rights and other such results belong to the national government and it is necessary to collect an appropriate fee for usage.	* For the results of international joint research involving consignment from the national government, the following treatment is permitted. (1) Sharing the patent rights or other rights related to the subject research results with the consignee. (2) Allowing the consignee to use the patent rights or other rights related to the subject research results at no cost or minimal cost.
Relinquishment of the right to claim for damages relating to international joint research conducted by thegovernment (Article 10)	It is often requested in international joint research to waive governmental compensation claims. To realize this, some legal basis should exist.	* For joint research with public organizations of foreign countries or international organizations conducted by the national government, it is possible for the national government to dispose its right to request compensation for damages.
Use of the government-owned facilities at low cost (Article 11)	To permit the use of national property at little expense, some legal basis should exist.	* Researchers, who are conducting research which is closely related to research being undertaken by the national government or may be of special value to the subject government research and will supply the results of such research to the national government, can use test and research facilities at a minimal cost.
What should be considered (Article 12)		* To conduct international research exchanges using special measures under this law, special attention shall be paid to fulfilling the obligation to execute treaties and other international promises and to maintain international peace and security.

In addition, the Research Development Corporation of Japan has accumulated abundant experience concerning performance of basic research by collecting together researchers from industry, universities and the national research institutes. The result of the partial amendment of the Research Development Corporation of Japan Law, (effective March, 1993) was to promote increased interaction between researchers and consolidate a system to comprehensively promote exchanges between researchers.

At present, in one system that promotes exchange between researchers, outside researchers participate in research at National Laboratories through guest researcher programs at each government ministry and agency. Exchanges between researchers are being promoted through the Research Development Corporation of Japan's National Institute Post Doctoral Fellowship Program and other research exchange programs. In addition, joint research is being promoted and research trusts are being conducted through joint research programs and research trust systems at each ministry and agency.

3.4.3.5 Activating Research Activities

The equipping of a flexible and competitive research environment which can bring out maximum creativity from researchers and the cultivation of a center of excellence which possesses a superior research environment which will attract outstanding domestic and foreign researchers are considered important in order to stimulate basic research and other research activities.

Accordingly, cooperation between industry, universities and national research institutes is being targeted through the promotion of joint research by each government ministry and agency. In particular, comprehensive project research is being promoted through cooperative programs involving industry, universities and national research institutes, such as comprehensive research on the Special Coordination Funds for Promoting Science and Technology, R&D into frontier technologies in biotechnology conducted at the Ministry of Agriculture, Forests and Fisheries, R&D into industrial science and technology at the Ministry of International Trade and Industry, and frontier R&D into telecommunications at the Ministry of Posts and Telecommunications. In addition, through cooperation between the Ministry of Education and other ministries and agencies, and through cooperative research guidance with national testing and research organizations, graduate level education is being promoted, and the mobilization of researchers is being promoted centered around outstanding leaders from national testing and research institutes to surpass the framework of the ministries and agencies and gather human resources internationally to promote creative basic research through basic research by ministries on the Special Coordination Funds for Promoting Science and Technology.

Increases in the total school expense per instructor and the total agency expense per researcher, which are mutual basic expenses that are absolutely necessary to carry out ordinary research at universities and national testing and research institutes, along with increases in the compensation portion of scientific research funds and Special Coordination Funds for Promoting Science and Technology, have been made with an aim to maintain a competitive environment in the area of supply of research funds.

A central research base (or "Center of Excellence" (COE)) cultivation program was set up using Special Coordination Funds for Promoting Science and Technology in 1993. The goal of this program is to raise the standards of specific research fields at public research organizations to a top world-class level. The program cultivates COE through the decisive implementation of basic research in the relevant fields in an adaptable and competitive environment. In the first year of the program, FY 1993, the three organizations chosen for cultivation were the Science and Technology Agency's National Institute for Research in Inorganic Materials (Tsukuba City, Ibaragi Prefecture), the Ministry of Welfare's National Cardiorascular Center Research Institute (Suita City, Osaka Prefecture), and the Agency of Industrial Science and Technology, Ministry of International Trade and Industry, National Institute of Bioscience and Human-technology (Tsukuba City, Ibaragi Prefecture), and the two organizations targeted in FY 1994 were the Ministry of Agriculture, Forests and Fisheries' National Institute of Agrobiological Resources (Tsukuba City, Ibaragi Prefecture) and the Ministry of Posts and Telecommunications' Communications Research Laboratory (Koganei City, Tokyo).

Furthermore, regarding the maintenance of conditions that will fully bring out the abilities of researchers, the Basic Policy for Securing Human Resources in the Fields of Science determined by the Prime Minister in December 1994 also points out that in order to sufficiently tap the potential of researchers and technicians, it is necessary to work at securing research funds as well as maintain an R&D environment which matches international standards in terms of facilities, equipment and research information base.

3.4.3.6 Dissemination of Information in Research Field and Distribution of Scientific and Technological Information

As work on the construction of an advanced information and telecommunications society being heralded as a new social revolution proceeds with an eye toward the 21st Century, in order for Japan, which is poor in energy resources, to achieve sustainable economic growth, it will be important to maintain a developmental base for the promotion of science and technology into the future. For this purpose, the need to establish and maintain an R&D environment of the highest level and to strive to improve research standards through promoting the dissemination of information in research fields is stressed.

The scientific and technological information created along with these activities are the fruits of R&D backed by advanced knowledge and a large amount of investment, and is one of the important foundations that supports the promotion of science and technology. In order to obtain accurate information promptly from the vast amount of scientific and technological information which is continuously growing year by year, it is increasingly important to gather and organize information into easily referenced systems so that it can be supplied in a form that meets the demands of individual users.

3.4.3.6.1 The Promotion of Research Information Networks

In light of the marked interdisciplinary and international nature of R&D activities in recent years and the quickly advancing level of knowledge and methods, the advancement of information networks in research fields is indispensable to Japan developing its R&D activities at an international level into the future. In addition to transcending limitations of time and space, and of department and field of specialty, the development of a research information network can revolutionize research activities by enabling the effective utilization of intellectual resources on a global scale and the development of effective cooperative international activities, and by creating new research areas and research methods.

In addition, just as Internet, which started from the U.S. as a research information network, has grown to be used in a variety of fields, the trailblazing activities of researchers in an advanced information system is expected to fulfill a leading role in order to encourage the development of information systems in society at large and to realize an advanced information and telecommunications society.

International efforts include the G7 Ministerial Conference on the Information Society held this February in Brussels, in response to the proposal made at the July 1994 Naples Summit. Centering on the seven leading nations, and based on international cooperation, work has begun on a Global Information Infrastructure (GII) for the goal of realizing a Global Information Society.

In recent years, Japan has made efforts to strengthen its research information data base infrastructure in order to contribute to the promotion of an efficient and effective research information network that transcends boundaries between research institutes, government ministries and agencies, and countries to connect research organizations, including the establishment of a Research Information Improvement/Inter-Ministry Network Promotion System from FY1994 with Special Coordination Funds for Promoting Science and Technology. However, in order to response to the ever-increasing need for dissemination of research information, it will be necessary to further the permanent maintenance of a research information base.

It will also be important to strive for a development balanced between hardware and software by continually improving the level and capacity of the information source (contents) which circulates throughout a network of data bases, along with advanced computational science and technology in ways that include upgrading utilization techniques of high-powered computers which operate on networks.

In particular, in light of the fact that information sources such as data bases and software which circulate on networks are at present dependent on the U.S. and Europe, it is necessary for Japan to quickly advance its infrastructure so that can actively provide scientific and technological information on the international level.

Efforts to build on Japan's research information network have centered around the Research Information Network Conference inaugurated by the Policy Committee of the CST in June 1993.

The conference compiled a report on Immediate Promotional Ways Relating to Research Information Network, which explains the relationship between the research information infrastructure and the R&D activities which utilize it as a multi-layered structure which appears in Figure 3-4-23. Six policies recommended for immediate development are mentioned:

①Promotion of the establishment of research information networks
②Promotion of uses (applications) of research information networks
③Promotion of the maintenance and distribution of information in research information networks
④The establishment of support systems for the research information networks
⑤Promotion of cooperation with other countries
⑥Discussions on the realization of free distribution and the system-related aspects of research information

The promotion of the maintenance and utilization of a research information base will firmly establish the information network in society as a whole, e.g., in educational, medicinal and industrial fields, and will take the lead toward an advanced information society, in addition to being one policy for the effective use of social capital. Furthermore, it is also stressed in the report that in order to increase Japan's overall research potential and strengthen the promotion of R&D, the relevant government ministries and agencies will need to come together to promote policy comprehensively and systematically.

Table 3-4-24 summarizes outline measures which are carried out by ministries and agencies concerned in FY1994.

3.4.3.6.2 Scientific and Technological Information Activities in Japan

The CST Recommendation pursuant to Inquiry No. 4, *Basic Guidelines Regarding the Distribution of Scientific and Technological Information,* submitted in October 1969, provides the basis for the promotion of scientific and technological information-related activities using the concept of a National Information System for Science and Technology (NIST).

Figure 3-4-23 Structure of research information infrastructure related to utilization of research and development activities

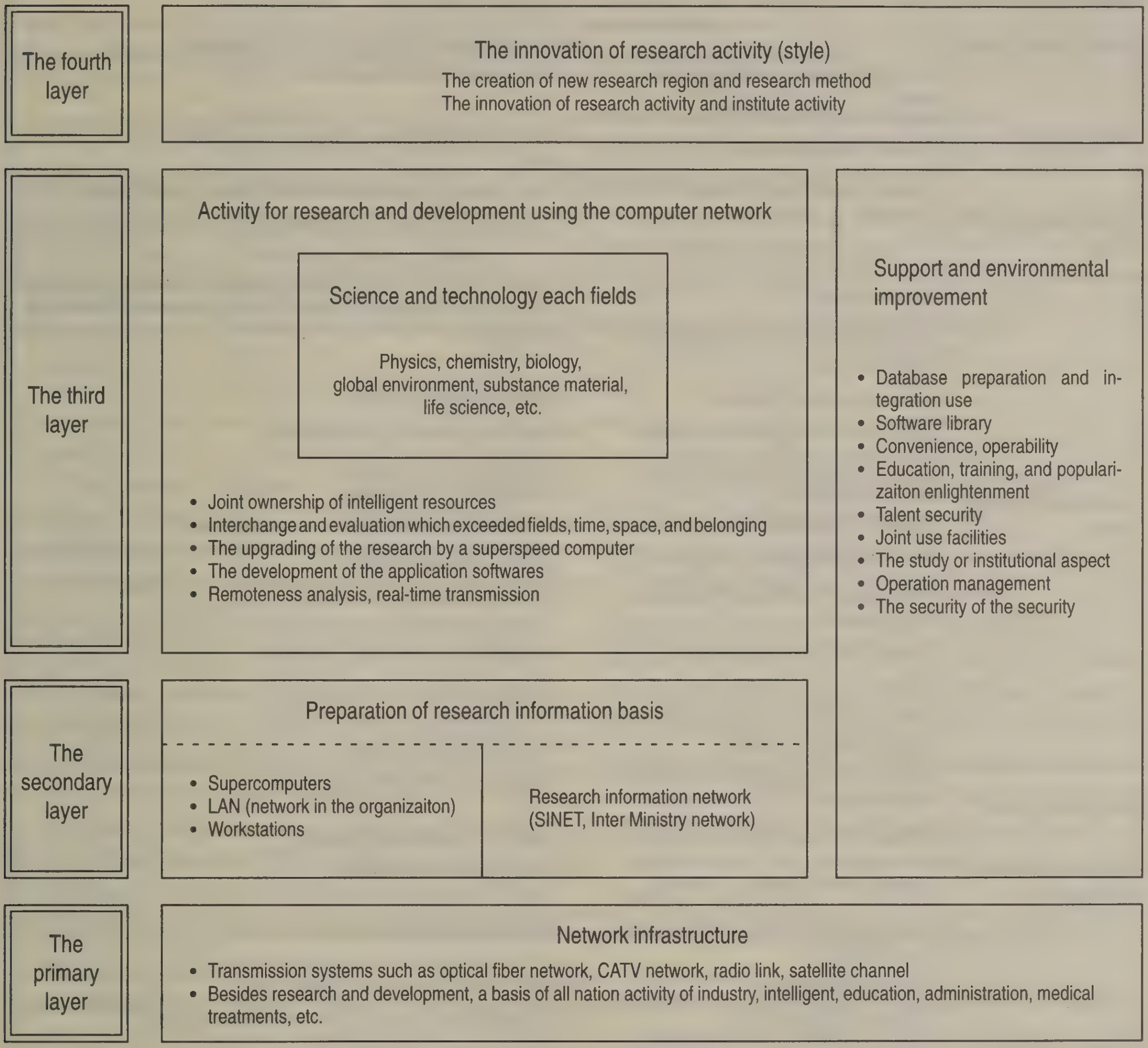

The fourth layer
The innovation of research activity (style)
The creation of new research region and research method
The innovation of research activity and institute activity
The third layer
Activity for research and development using the computer network
Science and technology each fields
Physics, chemistry, biology, global environment, substance material, life science, etc.
• Joint ownership of intelligent resources
• Interchange and evaluation which exceeded fields, time, space, and belonging
• The upgrading of the research by a superspeed computer
• The development of the application softwares
• Remoteness analysis, real-time transmission
Support and environmental improvement
• Database preparation and integration use
• Software library
• Convenience, operability
• Education, training, and popularizaiton enlightenment
• Talent security
• Joint use facilities
• The study or institutional aspect
• Operation management
• The security of the security
The secondary layer
Preparation of research information basis
• Supercomputers
• LAN (network in the organizaiton)
• Workstations
Research information network (SINET, Inter Ministry network)
The primary layer
Network infrastructure
• Transmission systems such as optical fiber network, CATV network, radio link, satellite channel
• Besides research and development, a basis of all nation activity of industry, intelligent, education, administration, medical treatments, etc.

Table 3-4-24 Distribution of science and technology information measures (in FY1994)

Ministry or Agency	Organization	Activity
National Diet Library		∗ Cost of purchasing scientific and technical materials ∗ Automation of library work
Science Council of Japan		∗ Expenses associated with joint international projects
Defense Agency	Technical Research and Development Institute	∗ Technical research headquarters LAN
	National Defense Academy	∗ Expansion and efficiency improvement in education, research and office work
	National Defense Medical College	∗ Data processing system at the National Defense Medical College
Economic Planning Agency		∗ Upgrading data systems for economic analysis and other purposes
Science and Technology Agency	Internal bureaus	∗ Research Information Improvement/Inter-Ministry Network Promotion System (Special Coordination Funds for Promoting Science and Technology)
	Internal bureaus, National Institutes, Public Corporations, etc.	∗ STA network
	National Aerospace Laboratory	∗ Numerical simulator loan fees
	Japan Atomic Energy Research Institute	∗ International technology data processing
	Japan Information Center of Science and Technology (JICST)	∗ Database conversion projects ∗ Expansion of on-line services
	Institute of Physical and Chemical Research	∗ Development and introduction of genome database
	Research Development Corporation of Japan	∗ Cost of providing research data
	Power Reactor and Nuclear Fuel Development corporation	∗ Computer system rental expenses
	National Space Development Agency of Japan	∗ Development of space station test modules
	Japan Marine Science and Techology Center	∗ Clerical costs associated with information
	Research Institute for Metals	∗ Cost of producing data sheets
Environment Agency	Internal bureaus, National Environment Research Institute	∗ System for providing environmental data
	National Environmental Research Intitute	∗ Operation of supercomputer system
National Tax Administration Agency	National Reseach Institute of Brewing	∗ Brewing test laboratory systems
Ministry of Education	National Center for Science Infornation Systems (NACSIS)	∗ Development of scientific information network
	Hokkaido University, etc.	∗ Development of mainframe computer center
	Fukushima University, etc.	∗ Development of campus data networks (university LAN)
	National Center for Science Infornation Systems (NACSIS)	∗ Promoting database development
	The Institute of Fluid Science of Tohoku University, etc.	∗ Supercomputers at research laboratories
	Public and Private Universities	∗ Installation of data processing equipment
Ministry of Health and Welfare	Internal bureaus	∗ Overall support systems for cancer diagnosis
	National Institute of Hygienic Sciences	∗ Operating costs associated with data use
	National Institute of Health	∗ Costs associated with development of research data network systems
Ministry of Agriculture, Forestry and Fisheries	Internal bureaus, etc.	∗ Operating costs associated with agriculture, forestry and fisheries computer centers

(Table 3-4-24)

Ministry or Agency	Organization	Activity
Ministry of International Trade and Industry	Internal bureaus	* Real world computing * Development Band funding of computer rental for education purposes (investment funding)
	Agency of Industrial Science and Technology (AIST)	* Development of research data base
	Patent Agency	* Overall automation of screening and testing procedures
	Information-technology Promotion Agency	* Development of software to promote advance data use in public fields
Ministry of Transport	Maritime Safety Agency	* Operation of marine data center
Ministry of Posts and Telecommunications	Internal bureaus	* Basic and cutting-edge technology (telecommunications frontiers)
	Communications Research Laboratory	* Operation of electronic computer systems
Ministry of Labor	Internal bureaus, etc.	* Costs associated with strategies to screen harmful substances
Ministry of Construction	Comprehensive Technological Development Project	* Creative technology for esthetically pleasing surroundings

In December 1989, in its Recommendation pursuant to Inquiry No. 16, *Basic Guidelines for Managing the Infrastructure for Science and Technology Promotion,* the CST outlined the importance of a healthy promotional infrastructure, including scientific and technological information. To facilitate this, the CST proposed implementations of the following measures:

- Reinforcement of the information distribution infrastructure with an emphasis on improving the quality of information and ensuring easy access to information by users
- Furthering of international distribution of information and the dissemination of information among regional areas in Japan
- Intensified and broader information collection
- More advanced information dissemination capabilities

The Recommendation pursuant to Inquiry No. 18, *General Basic Policies on Science and Technology for the Next Century* submitted in January 1992 proposes the following:

- Facilitation of the distribution of document information
- Preparation of an information distribution system to promote the construction of a factual data base and its usage
- Strengthening of the mutual distribution function of international information
- Regional development of a science and technology information network

In response to these recommendations, the *General Guideline on Science and Technology Policy* revised in April 1992 calls for expansion in production of science and technology information and in its distribution in Japan and overseas, and the regional development of a science and technology information network.

Other than those mentioned above the following sections summarize science and technology information activities in Japan.

3.4.3.6.2.1 Primary Information Services

Libraries and several other information service organizations make primary literature available for reading, photocopying or loan. According to the National Diet Library (NDL) Law, all unclassified publications issued in Japan are to be deposited in NDL. The library has created a database of its collection and has made this available for use on-line.

The Ministry of Education's National Center for Science Information Systems (NACSIS), in cooperation with national and local governments and private universities and colleges, has created a database that catalogs the location of books and magazines available in university libraries nationwide and made this information available for referencing.

3.4.3.6.2.2 Secondary Information Services

The use of computers to edit and build databases allows researchers to search large volumes of data quickly, accurately and with relative ease.

Recently, the creation and utilization of databases in science and technology fields has increased sharply worldwide.

The Japan Information Center of Science and Technology (JICST) produces the comprehensive bibliographic database, inputting approximately 700,000 science and technology documents in all the science and technology fields which are collected from more than fifty countries annually, and provides this by Jicst Online Information System (JOIS). The center also provides factual databases such as Chemical Dictionary Database of Chemical Substances.

NACSIS creates databases for use in scientific research, providing this information nationwide over a scientific information network that links national, local governments' and private universities and related organizations.

The Japan Patent Information Organization (JAPIO) has created a database of patent information that is provided by an online service called PATOLIS.

3.4.3.6.2.3 Clearing Services

Clearing services provide information on specific research topics. JICST supplies on-line information on a variety of research topics from public research institutes which is available on JOIS.

NACSIS has created and provides on NACSIS-IR an on-line database containing abstracts of research funded by Grant-in-Aid for Scientific Research.

3.4.3.6.2.4 International Dissemination of Scientific and Technological Information

Overseas demand for Japanese scientific and technological information has increased as the nation's science and technology has progressed.

In November 1987, the three organizations of JICST, the Chemical Abstracts Service (CAS) of the United States and FIZ Karlsruhe of Germany set up the Scientific and Technical Information Network International (STN International) which currently provides a service well exceeding a hundred different types of databases.

NACSIS also has been disseminating internationally Japanese scientific information by exchanging information with research organization overseas, by supplying information retrieval service on Internet.

Since FY1990, JICST has been promoting dissemination abroad government documents in science and technology fields which had hitherto been difficult for overseas researchers to obtain. In March 1993, JICST held an explanatory meeting on Japanese scientific and technological information in June 1993 in Paris, France and in July 1994 in Boston, United States.

3.4.3.6.2.5 Advancement of R&D Related to Scientific and Technological Information

The "Investigations for Building a Self-Organizing Information-Based System to Assist Creative R&D" program, which was begun in FY1990 to support researchers' creative R&D activities and was financed using the Special Coordination Funds for Science and Technology. In FY1994, discussions aimed at upgrading each elemental technologies and strengthening system integration were conducted. In addition, the following programs have been initiated through the Research Information Improvement/Inter-Ministry Network Promotion System established with the FY1994 Special Coordination Funds for Promoting Science and Technology.

- Studies and Research on Basic Technologies Involved in the Maintenance and Operation of the Ministry Network
- Studies and Research on Creating Data Bases for Data Related to Substances (effects on living bodies, food product ingredients, surface analysis)
- Research on Creating Data Bases for Earth Observation Data

3.4.3.7 Science and Technology Promotion at Regional Level

The Cabinet in its *Fourth Comprehensive National Development Plan,* approved in June 1987, and the *General Guidelines for Science and Technology Policy,* approved in April 1992, identified the strengthening of regional R&D capability as a strategic issue for activate regional community. In order to set basic indicators for policies which are considered priority policies in these Guidelines, Inquiry No. 22 *Basic Guidelines for Boosting Regional Scientific and Technology Activities* was submitted to the CST in June 1994.

Japan's regional areas held councils and meetings deliberating measures for development of science and technology and formulated general principles and guidelines for science and technology policy and have begun actively developing science and technology (Table 3-4-25 and 3-4-26).

Hitherto, R&D advances in regional areas have been centered on the work of public laboratories. More recently, with improvement in the technological development capability of regional industries, many local governments are considering reorganization and rearrangement of public laboratories.

New measures for development of science and technology at the local government level have been appearing. These include the determination of a science city concept in the region and the establishment of a public corporation as a core organization for promoting comprehensively scientific and technological development.

Here, we will various measures taken by the central government to develop science and technology in the regions (Table 3-4-27).

3.4.3.7.1 Measures for Interaction Within and Outside Regional Areas

3.4.3.7.1.1 Adviser Meeting on Local Science and Technology Policy and Forum on Local Science and Technology Policy

To better promote regional and national science and technology through the science and technology policy, the Council for Science and Technology, in cooperation with the science and technology committees set up in each prefecture, began Adviser Meetings on the Science and Technology Policy in FY1991 between the members of the Council's Committee on Policy Matters and the chairmen of prefectural science and technology committees to exchange opinions on science and technology policy. Also, to discuss questions of regional science and technology policy and include not only experts directly involved in formulating regional science and technology policy, but also experts related in some way to such policy, and researchers themselves, The Forum on Local Science and Technology Policy was started in FY1992.

Table 3-4-25 Establishment state of science and technology council by local governments organizations

Prefecture	Name of science and technology council	Established	Chairman	Composition
Hokkaido	Hokkaido Science and Technology Council	September 1952	Tsutomu Hiroshige, The President of Hokkaido University	30 experts from industries, universities and government
Kyoto	Kyoto Science and Technology Council	September 1961	Takao Okada, Kyoto University Professor Emeritus	15 scholars
Ishikawa	Ishikawa Technology Promotion Council	August 1982	Takeshi Yasui, Kanazawa University Engineering Professor	12 experts from industries, universities and government
Toyama	Toyama Science and Technology Council	November 1983	Tomomichi Yanagida, University of Tokyo Professor Emeritus	20 experts from prefectural industries, universities and government
Hyogo	Hyogo Science and Technology Council	July 1986 - March 1992	Nobuaki Kumagai, Osaka University Professor Emeritus	21 experts from industries, universities and government
Osaka	Osaka Science and Technology Deliberations Committee	December 1986	—	7 experts from industries, universities and government
Kanagawa	Kanagawa Science and Technology Council	June 1988	Saburo Nagakura, President of Kanagawa Academy of Sience and Technology Foundation	17 experts from industries, universities and government
Iwate	Iwate Science and Technology Promotion Council	April 1989	Iwao Kudo, Governor of Iwate Prefecture	executives of the prefectural government
Yamaguchi	Yamaguchi Science and Technology Council	May 1991 (suspended from March 1994)	Yoshihira Tanaka, Tokyo Institute of Technology Professor Emeritus	12 experts from industries, universities and government
Yamanashi	Yamanashi Science and Technology Council	September 1991	Satoshi Omura, Kitazato Research Center Head	16 experts from industries, universities and government
Hiroshima	Hiroshima Science and Technology Promotion Conference	May 1992 - March 1994	Noriyasu Yoshida, Hiroshima University Assistant Dean	17 experts from industries, universities and government
Saga	Investigating Committee for Science and Technology Strategies in Saga Prefecture	August 1993 - March 1995	Shigehiko Ito, Saga University Professor Emeritus	12 experts from industries, Universities and government
Chiba	Chiba Science Council	November 1994	Minoru Oda, President of Tokyo University of Information Science	10 scholars
Saitama	Saitama Science and Technology Council	November 1994	Akito Arima, President of Institute of Physical and Chemical Research	17 scholars

Table 3-4-26 Enactments of science and technology promotion policies by local governments

Prefecture	Science and technology promotion policy	Date of enactment
Osaka	Osaka Research and Development Charter	March 1988
Shizuoka	Basic Direction of Science and Technology Promotion Policies in Shizuoka Prefectur	January 1990
Saitama	Saitama Technology Policy for the 21st Century	February 1990
Iwate	Guidelines for Promoting Science and Technology in Iwate Prefecture	May 1990
Kanagawa	General Guideline for Kanagawa Science and Technology Sixth Plan	May 1990
Hyogo	General Guideline for Hyogo Science and Technology Sixth Plan	March 1991
Hokkaido	Basic Direction of Science and Technology Promotion Policies in Hokkaido	April 1991
Toyama	General Guideline for Toyama Science and Technology	October 1991
Yamanashi	Yamanashi Science and Technology Sixth Plan	March 1992
Hiroshima	Fundamental Principles of the Promotion of Science and Technology in Hiroshima Prefecture	November 1993
Ibaraki	General Outline of Science and Technology Strategies in Ibaragi Prefecture	March 1994
Yamaguchi	Guidelines for the Promotion of Science and Technology in Yamaguchi Prefecture	March 1994
Kyoto	Plomotion Plan for Industry and Technology in Kyoto	February 1995

3.4.3.7.1.2 Regional Science and Technology Promotion Conference

As a part of the measures to promote science and technology in regional areas, the Science and Technology Agency has divided the entire country into eight separate blocks and has held Regional Science and Technology Promotion Conferences for each block. The conferences seek to encourage an environment for closer cooperation among science and technology organizations, the industrial community and the academic community and to contribute to stabilizing, the science and technology promotion infrastructure in regional areas. At these conferences, representatives from the various sectors, especially those related to science and technology, come together and look at differences in national and regional opinions concerning science and technology and the issues surrounding the promotion of science and technology in that region.

3.4.3.7.1.3 Japan Association for the Advancement of Research Cooperation (JAREC)

The Japan Association for The Advancement of Research Cooperation was established in June 1992 with funds provided by the prefectures to engage in various activities that contribute to promoting regional science and technology. An office is located in the Tsukuba Science City. This association conducts various research support activities and research exchange promotion activities nationally when regional areas begin research in advanced or basic research areas.

3.4.3.7.2 National Research System for Research and Development in Regional Areas

The relevant ministries and agencies have set up a variety of research systems in order to conduct R&D in regional areas. The following section introduces some of the main examples.

Table 3-4-27 Major Regional science and technology promotion measures

Ministry or Agency, related organizations	Item	Outline of measures
Science and Technology Agency	Joint research utilizing science and technology potential region (Special Coordination Funds for Promoting Science and Technology)	Outstanding researchers not only from the region but also from outside the region and engaged in researches which serve regional development and improvement of living standard for the residents.
Science and Technology Promotion Bureau	Promotion of regional research exchanges (Regional Research communication Networks)	Promotion of information distribution and new technology corporations centering on the new technology coordinator for regional research information networks in order to advance regional research and development functions.
Institute of Physical and Chemical Research	Frontier research and regional development	Joint research is conducted with the cities and prefectures on new technology issues with activities centering around regional research organizations.
Japan Marine Science and Technology Center	Regional joint research and development projects	Joint research is conducted with the cities and prefectures on technology issues that must be overcome in order to promote the comprehensive use of regional ocean territory.
Environmental Agency, Planning and Coordination Bureau	Research Funds for the National Organization for Pollution Prevention (Research to meet regional needs)	Public facility joint research is conducted with national testing and research organizations concerning research issues matched to specific regional needs.
Ministry of Agriculture, Forestry and Fisheries, Agriculture, Forestry and Fisheries Research Council Secretariat	Regional biotechnology research and development promotion project	Public facility testing joint research with regional agricultural testing sites of the Ministry of Agriculture, Forestry and Fisheries in high-tech areas of research and development.
	Joint research with prefectural agricultural testing sites	In terms of important research issues stemming from the demands of agricultural testing sites, in addition to public facility testing joint research conducted with the national research facilities of the Ministry of Agriculture, Forestry and Fisheries, the nation's researchers enter the local areas directly and, through close links with public facilities testing, conduct technological development necessary for securing the large-scale high-productivity agricultural industry needed to meet the actual regional conditions.
	Joint research system for public and private exchange (regional technology joint research)	In terms of special research issues that need to be immediately resolved, regional agricultural testing sites and local public facilities testing are linked and research is conducted.
Ministry of International Trade and Industry, Agency of Industrial Science and Technology	Important regional technology research and development system	Joint research is conducted on important technology issues that meet specific regional needs.

3.4.3.7.2.1 Science and Technology Agency

The Science and Technology Agency, using Special Coordination Funds for Promoting Science and Technology from FY1990, has initiated a regional research program. The program assembles at regional research organizations, top researchers from within and outside the region and employs the special characteristics of the region to conduct basic and leading research which contributes to improving Japan's level of science and technology. Since FY1992, contributing to the improvement of the living standards of local people has been added as a theme. This program is being expanded under the title of Joint Research Utilizing Scientific and Technological Potential in Region.

This research takes place under a central regional organizer who guides research efforts. Researchers from national research institutes, universities, local government research institutes and private companies are brought together to strongly encourage research.

The Japan Marine Science and Technology Center (JAMSTEC) has implemented a joint research and development program since 1988. It involves joint research with prefectures to advance marine science and technology, to disseminate knowledge on these and to promote the usage of sea areas in regions.

3.4.3.7.2.2 Environment Agency

Since FY1993, the Environmental Agency has been performing environmental research closely related to local regions as joint research together with national research institutes and public research institutes into issues which are of strong concern to regions and which should be examined as a result of he characteristics of the regional environment.

3.4.3.7.2.3 Ministry of Agriculture, Forestry and Fisheries

Since FY1984, the Ministry of Agriculture, Forestry and Fisheries has been carrying out joint research with the Ministry's research institutes and public research institutes into important research issues on the basis of requests made by public agricultural research organizations. In addition, since FY1986 the Ministry's regional agricultural research institutes and public research institutes have been promoting regional biotechnology R&D in the form of joint R&D activities in the field of biotechnology.

The Ministry has implemented regional, concentrated, cooperative, technology research since FY1992. This effort brings together regional agricultural testing plants, local government research institutes and private companies to cover research themes related to regional research needs.

In addition, the Ministry is implementing, mainly at regional agricultural testing grounds, research on topics that meet regional research needs through private sector and government exchange joint research which actively incorporates private sector technological knowledge.

3.4.3.7.2.4 Ministry of International Trade and Industry (MITI)

Since FY1982, the Ministry of International Trade and Industry has implemented the Priority Regional Technology Research and Development System. In this program, the Agency of Industrial Science and Technology's (AIST) testing laboratories, local government research institutes and private companies join together to conduct research and development on priority research and development themes which meet regional needs or take advantage of regional research and development potential.

3.4.3.7.3 Support for Concentrating Research and Development Functions

In the past, policies for industrial promotion in regional areas have focused on attracting or relocation of plants. The importance of attracting research facilities and advanced industrial technologies is being recognized now as a more effective approach. It is now felt that comprehensive development, in which organizations to support research are provided and living and recreational environments are improved, is also necessary.

3.4.3.7.3.1 Technopolis Regulation (High-Technology Industry Intensive Area Development Promotion Regulation)

By the word technopolis, they seek to promote the concentration of advanced technology industry in regional areas and the creation of urban areas which assemble industry, academia, and living facilities around an advanced technology by preparing infrastructure for various types of industry. As of the present, programs in 26 regions have been approved.

3.4.3.7.3.2 Key Facilities' Siting Law-Law to Promote the Group-Siting of Designated Types of Business Contributing to More Sophisticated Local Industrial Structures

With the increasing shift to software and service in economic activities, the Key Facilities' Siting location Law promotes basic facility equipping operations in each industry with a goal to combine the regional distribution of plants with the raising of the level of regional manufacturing by accumulating industrial support service operations for such areas as natural science research institutes, the software industry and the information processing service industry to promote the regional distribution of plants.

At present, programs for 26 regions have been approved.

3.4.3.7.3.3 Multi-Polar Act-Act on the Promotion of Multi-Polar Pattern National Land Formation

The development of regional research bases in line with the Multiple-Polar Act is designed to develop and establish wide-ranging regional promotion bases in a comprehensive and strategic manner by concentrating industrial, cultural, scientific, research and exchange functions which are distinct to the region and to strongly support regional development led by regional forces.

3.4.3.7.3.4 Private Sector Resources Utilization Law-Temporary Law for Promoting the Strengthening of Specific Facilities by Utilizing Private Sector Business Capabilities

The Private Sector Resources Utilization Law was passed in May 1986. It is designed to promote utilization of the capabilities of the private sector in providing facilities which strengthen the economic and social infrastructure. The facilities related to research and development are grouped in four categories: research core facilities which are dedicated to research and development and commercialization of industrial technologies; telecommunications research park facilities which are designed for research and development of telecommunications technologies; agriculture, forestries and fisheries research and development and commercialization infrastructure facilities; and the coastal regions revitalization facilities.

3.4.3.7.4 Promotion of Information Dissemination

3.4.3.7.4.1 Promotion of Regional Research Exchanges-Regional Research Communication Networks

The Science and Technology Agency started a research information network in regional areas in FY1988. Based on this, the Agency has striven projects to promote research exchange, information exchange within the region and between regional areas and the Tsukuba Science City and to encourage the development of new technologies. Also, these various regional research information networks are connected with the Tsukuba Science City Tsukuba Network, thus contributing to interaction between regional areas and Tsukuba.

3.4.3.7.4.2 Other National Information Networks

The Japan Information Center of Science and Technology (JICST) has created a comprehensive database of documents on science and technology and provides this on-line through the JICST network. Branch offices are located in 10 locations nationwide and are used by regional researchers.

National and International Networks of Science Information centered on the National Center for Science Information are connecting national, public and private universities nationwide is being developed.

Since August 1993, an information retrieval service and other services have been made open to the public for use by researchers outside universities and other people.

The on-line Patent On-Line Information System provided by the Japan Patent Information Organization started service in 1978. In addition, the Japan Technomart Foundation which distributes technical information has branch offices in 10 regions.

3.4.3.7.5 Consolidation of R&D bases

The fourth Comprehensive National Development Plan calls for the consolidation of Tsukuba and the hilly area of Kyoto, Osaka and Nara as a base for cultural, academic and research activities. It also calls for a research institute city to be established in the regions making use of the characteristics of each region, and for the creation of a network to link these to R&D

and other activities.

3.4.3.7.5.1 Tsukuba Science City

Tsukuba Science City has been created as a base to provide a high level of research and education in addition to contributing to the well-balanced development of the entire Tokyo metropolitan area. It is being constructed as part of the national policy to respond to the needs of the age as regards science, academic research and advanced education.

In this city, currently, 47 national research institutes, educational organizations and the like have been established and are operating. Private research organizations are also moving into the city.

The city is developing in this manner, and is promoting the establishment of facilities from both within Japan and overseas which are fostering its development as an R&D base.

3.4.3.7.5.2 Kansai Science City (Kyoto, Osaka and Nara Prefectures)

Kansai Science City seeks to take advantage of the abundant culture, science, and research cultivated by the Kinki area over many years as the foundation of a new base for international, interdisciplinary, and interactive culture, science, and research. It is being developed based on the Kansai Science City Construction Promotion Law.

3.4.3.8 "Cooperative Technology Development" and "Technology Transfer Facilitation"

The Research Development Corporation of Japan (JRDC) surveys and compiles experimental research results at universities, national research institutes and other research organizations to pick out promising results, and under "Cooperative Technology Development" System contacts with companies to develop those results which otherwise would be difficult to be commercialized. In this way JRDC actively promotes the commercialization of new technologies. JRDC also makes available the developed technology so that it can be used by companies in the private sector.

For new technologies which can be developed on a commercial basis with relatively small risks, JRDC promotes their transfer to companies through "Technology Transfer Facilitation" activity. JRDC promotes technology transfer to foreign countries by publishing an English-language magazine introducing new technologies possible for licensing overseas.

By the end of FY1994, 296 "Cooperative Development of Industrial Technology" projects were successful and 523 experimental research results were transferred to 837 companies.

3.4.3.9 Promotion of Research in the Private Sector

3.4.3.9.1 Promotion through Preferential Taxation and Financial Provisions

The government is promoting the smooth development of research activities and the advancement of new technology through preferential taxation and financial provisions for private-sector research expenditures.

Tax benefits within the national taxation system include *The Tax Deduction on Experimental and Research Expense Increments,* instituted in FY1967. This program has been a major factor in encouraging the expansion of private-sector research activities based on independent and innovative efforts. This allows corporations to deduct from their tax assessment 20% of the incremental increase over their previous highest expenditure for research.

Another preferential tax measure, adopted in FY1985, is *The Tax Program for Promoting R&D of Basic Technologies* which exempts businesses from 5% of the acquisition cost of assets, such as equipment and facilities, purchased for the purpose of conducting R&D in the basic technology areas.

Another measure of this type adopted in the same year is *The Tax Deduction for Strengthening the Technological Foundation of Small-*

and Medium-scale Enterprises. This program, which may be selected as an alternative to *The Tax Deduction on Experimental and Research Expense Increments,* allows small-and medium-sized enterprises to deduct from their assessment a maximum of 6% of their overall research expenditures every tax year.

Similar preferential tax provisions to *The Tax Program for Promoting R&D of Basic Technologies* and *The Tax Deduction for Strengthening the Technological Foundation of Small- and Medium-scale Enterprises* were adopted as special measures in local taxation structures and provide for reductions in the standard taxation determined by the corporate residential tax rate. See also Table 3-4-28 for a summary of the main tax provisions for promoting science and technology.

3.4.3.9.2 Promotion through funding and loans

A variety of organizations have provided assistance in the forms of funding and loans in order to promote R&D activities in the private sector. The following section introduces some of the main examples.

3.4.3.9.2.1 Japan Key Technology Center

Japan Key Technology Center was established in October 1985 with the aim of promoting experimental research in the private sector concerning fundamental technology in the mining, engineering, telecommunications and broadcasting industries. Using funds from the Industry Investment Special Account, the Japan Development Bank and private sources, the Center provides conditional interest-free loans and funds, and encourages joint research activities. In FY1995, funds from the Industry Investment Special Account totaled 26,000 million yen.

3.4.3.9.2.2 Bio-oriented Technology Research Advancement Institution

This institution was established in October 1986 with the aim of promoting experimental research in the private sector concerning designated industrial technology of biological systems. Using funds from the Industry Investment Special Account and private sources, the institution provides conditional interest-free loans and funds, and encourages joint research activities. In FY1995, funds from the Industry Investment Special Account totaled 3,300 million yen.

3.4.3.9.2.3 Organization for Drug ADR Relief R&D Promotion and Product Review

This organization started operating in October 1987 with the aim of promoting experimental research in the private sector concerning medical products technology and similar matters. Using funds from the Industry Investment Special Account and private sources, the Found provides conditional interest-free loans and funds, and encourages joint research activities. In FY1995, funds from the Industry Investment Special Account totaled 2,300 million yen.

3.4.3.9.2.4 Other financial provisions

There are also a number of financial provisions designed to help raise the nation's level of technological development through the provision of low-interest loans. These include the Financing for Development and Promotion of Technology administered by the Japan Development Bank's Domestic Technology Promotion Funding System. The Technology Promotion Funding System provided loans totaling 83,500 million yen during FY1994.

Further, Japan Finance Corporation for Small Business has established the Loan for the Development of New Industries and Technology to stimulate new technology development and further technological advancement at small- and medium-scale enterprises.

Table 3-4-28 Major preferential for science and technology promotion (as of April, 1995)

Item	Purpose	Description	Applicable law	Date of enactment / validity
Tax Deduction Programs on Experimental and Research Expense Increments and others ① Tax Deduction on Experimental and Research Expense Increments	Promotion of technological development	[National Taxes] 1. Corporations can deduct 20% of the incremental increase in research expenditures form their tax assessment (with an upper limit of 10% of their tax assessment) provided that the research expenditures for the applicable tax year (the amount debited against income) exceed the maximum annual research expenditure for all tax years falling between the standard tax year (defined below) and the immediately preceding business tax year. In addition, corporations may treat 20% of investments in approved experimental research companies as a research expenditure. Research expenditures include the payment to outside institutions undertake consigned R & D, the payment levied to members of the Mining and Manufacturing Technological, Research Association by the Association and the amount equivalent to 20% of stock acquision cost of approved experimental research companies. Notes: Applicable tax years: All business years starting between June 1, 1967 and March 31, 1995 Standard tax years: Business tax years immediately preceding the business tax year in which January 1, 1967 falls 2. Identical provisions apply to individuals	Special Taxation Measures Law, Article 10, Item 1 (personal income tax), Article 42-4, Items 1,6 (corporate income tax)	Enacted in FY1967, effective through FY1994
② Tax Program for Promoting the R&D of Basic Technologies	Promotion of technological development	[National taxes] 1. In addition to the current Deductions on Experimental and Research Expense Increments, corporations may deduct from their tax assessment 7% of the acquisition cost of depreciation assets to be used for R&D of basic technologies (assets for the R & D of basic technologies), including special materials, biotechnology, advanced electronics technology, mechatronics technology, and space-development, with an upper limit of 15% of their tax assessment. 2. Identical provisions apply to individuals	Special Taxation Measures Law, Article 10, Item 2 (personal income tax), Article 42-4, Item 2 (corporate income tax)	Enacted in FY1985, effective through FY1994
		[Local taxes] 3. Corporations may deduct 7% of the acquisition cost if assets to be used for R&D of basic technologies from the standard taxation determined by corporate residential tax rate, with an upper limit of 15% of the standard taxation.	Local Taxation Law, Supplementary Provisions, Article 8, Item 1	Enacted in FY1985, effective through FY1994

(Table 3-4-28)

Item	Purpose	Description	Applicable law	Date of enactment / validity
③ Tax Program for Strengthening the Technological Foundation of Small and Medium-scale Enterprises	Promotion of technological development	[National taxes] 1. As an alternative to taking the Deductions on Experimental and Research Expense Increments, small and medium-scale enterprises paying corporate income taxes may choose to take a tax deduction of 6% of their research expenditures with an upper limit of 15% of their tax assessment. In addition, they may treat 20% of investments in approved experimental research companies as a research expenditure. Applicable experimental expenditures are the same to them of tax deduction on experimental and research expense increments. 2. Identical provisions apply to individuals	Special Taxation Measures Law, Article 10, Item 3 (personal income tax) Article 42-4, Items 3,6 (corporate income tax)	Enacted in FY1985, effective through FY1994
		[Local taxes] 3. Small and medium-scale enterprises opting for the 6% deduction above may deduct this amount from the standard taxation determined by the corporate residential tax rate, with an upper limit of 15% of the standard taxation.	Local Taxation Law, Supplementary Provisions, Article 8, Item 2	Enacted in FY1985, effective through FY1994
④ Tax Deduction for Promoting on Special Experimental and Research Expenses	Promotion of technological development	[National Taxes] 1. For experimental research expenses related to joint research with national testing and research organizations and for experimental research expenses related to technology involving technology for the rationalization of energy use and specific substance use, the following totals are recognized as tax deductions. (However, this is limited to corporate taxes of 10%, or 15% if (2) applies). (1) 6% of the relevant amount for special experimental research expenses for the applicable fiscal year. (2) 7% of the acquired amount in cases where there is acquisition of capital for basic technology research anddevelopment. (3) 20% of the least relevant amount if either the amount for (a) or (b) below are added. (a) Amount of testing research expenses for the applicable fiscal year - Amount of comparative experimental research expenses. (b) (Amount of testing research expenses for the applicable fiscal year - amount of special testing research expenses for the applicable fiscal year) - (amount of comparative testing research expenses - amount of special testing research expenses for the business year in which the amount of comparative testing research expenses has been paid) In cases where there is investment in special testing research companies, it is possible to add 20% of the relevant amount for investment to the amount of testing research expenses for the applicable fiscal year in (3) (a) and (b) above. 2. Identical provisions apply to individuals	Special Taxation Measures Law, Article 10, Item 4 (personal income tax), Article 42, Item 4,5,6 (corporate income tax)	Enacted in FY1993, effective through FY1994

(Table 3-4-28)

Item	Purpose	Description	Applicable law	Date of enactment / validity
Special Exemption of Income Associated with Overseas Transactions Related to Technology Transfers	Promotion of diverse types of overseas transactions and the promotion of technology transfers and domestic technology development	1. Corporations receiving income from overseas transactions related to technology transfer are exempt from a portion of this income (not to exceed 35% of applicable tax year's income) as a debit against taxable income. Specifically, they are exempt from: ∗ 7% of income from the supply or transfer of industrial property rights (excluding trademark rights) and know-how. ∗ 14% of income from consulting activities. 2. Identical provisions apply to individuals	Special Taxation Measures Law, Article 21 (personal income tax) Article 58, (corporate income tax)	Enacted in FY1964, effective through FY1995
Exemption of Donations and Contributions				
1. Specific donations	Promotion of education, science and technology	Where emergency funds required for education, science or similar purpose are solicited widely in the form of general donations, corporations may enter the total sum as a loss, while individuals may claim deductions under the "special donation" category.	Corporate Taxation Law, Article 37, Item 3 Personal Income Taxation Law, Article 78, Item 1,2	Enacted in FY1961 Tax exemption method enacted in FY1962 and revised in FY1967
2. Contributions to specified public-service trusts		1. Corporations Corporations may enter the amount of their donations as a separate item of debits-against-income and distinct from general donations. The upper limit is the same as that for general donations. 2. Individuals The income tax exemption can be applied to each donation to a specified public benefit corporation.	Corporate Taxation Law, Article 37, Item 5 Personal Income Taxation Law, Article 78, Item 1,3	Enacted in FY1987
3. Donations to specified public-corporations. See note.		Corporations and individuals can apply exemptions for donations to approved public-service trusts by including the amounts of these donations in the totals for donations to specified public-service promotion corporations. Corporations should then calculate debits against income, while individuals calculate income taxexemption. Note: Deduction of donation = Total value of special donation (limited to 25% of income) less ¥10,000	Corporate Taxation Law, Article 37, Item 3, Personal Income Taxation Law, Article 78, Item 1,2	Enacted in FY1987
Measure for Exceptional Treatment of Fixed Asset Acquisitions for Experimental Research by the Mining and Industrial Technology Research Cooperatives	Promotion of technological R&D	1. Members of the Mining and Manufacturing Technological, Research Association may apply special depreciation to payments levied by the Association to acquire fixed assets for experimental research. 2. The Mining and Industrial Technology Research Cooperatives may enter the value of fixed assets acquired for experimental research by levy on members in its account books as 1 yen	Special Taxation Measures Law, Article 18 (personal income tax), Article 52 (corporate income tax) Special Taxation Measures Law, Article 66-10	Enacted in FY1961, effective through FY1992 Enacted in FY1961, effective through FY1992
Measure for Tax Exemptions on Research Assets of Scientific Research Corporations	Promotion of science and technology	Assets provided to corporations established under Civil Law Article 34 for the purpose of scientific research are exempt from the real estate acquisition tax, fixed assets tax, special land holding tax and urban planning tax on investments used directly for- that research.	Local Taxation Law, Article 73-4, Item 1, Article 348, Article 586, Article 702-2	Fixed asset tax enacted in FY1951, real estate acquisition tax, in FY1954, urban planning tax, in FY1956, special land holding tax in FY1973

(Table 3-4-28)

Item	Purpose	Description	Applicable law	Date of enactment / validity
Fixed Asset Tax Reduction Measure for Machines and Equipment for Research Acquired by the Mining and Industrial Technology Research Cooperatives	Promotion of technological development	The standard of assessment for the machinery and equipment fixed assets approved under the regulations of the Mining and Industrial Technology Research Cooperatives Law, Article 14 and additionally acquired between April 1, 1993 and March 31, 1995 is valued at five-sixth of the standard value for period of three years from the year in which tax was first levied on the asset.	Local Taxation Law, Supplementary Provisions, Article 15, Item 26	Enacted in FY1962, from FY1993,applicable for the first two years after acquisition

3.4.4 International Exchange of Science and Technology

3.4.4.1 Bilateral Cooperation

3.4.4.1.1 Cooperation with Industrialized Nations

Cooperation between Japan and other industrialized nations is conducted mainly on the basis of bilateral agreements. Cooperative goals include solutions to problems common to the nations related to natural resources development, energy development, nuclear energy, space development, ocean development, biotechnology and environmental protection.

Japan and the United States have been cooperating in this area since the Japan-U.S. Science and Technology Cooperation Agreement was concluded in June 1988. (Extended in June 1993.)

So far, an active exchange of opinions has taken place on a variety of levels, including five meetings of the Joint High-Level Committee chaired at the ministerial level, six meetings of the Joint Working-Level Committee that laid the groundwork for the Joint High-Level Committee, and five meetings of the Joint High-Level Advisory Panel of experts from the two countries. In addition, two Task Forces met to investigate issues of the participation of researchers in R&D and access to scientific and technological information of each country.

In 1994, 60 U.S. graduate students joined Japan's public and private research institutes for approximately 2 months from June to August. This program, the 5th Summer Institute was carried out by Task Force on access to R&D (TFA) which has established under the framework of the Japan-U.S. Agreement on Cooperation in Research and Development in Science and Technology and sponsored by National Science Foundation (NSF), National Inseitutes of Health (NIH) and the Center for Global Partnership of the Japan Foundation.

Cooperation in fields such as nuclear fusion and high-energy physics is being conducted under the Japan-U.S. Energy R&D Agreement (concluded in May 1979, revised in February 1990). In February 1995, this agreement was prolonged for another five years.

Japan-U.S. cooperation in the area of space development has been based on US/Japanese Agreement on Space Cooperation concluded in July 1969, and under the supervision of the Standing Senior Liaison Group establish in July1979 based on the mutual agreement between the Space Activities Commission and the National Aeronautics and Space Administration (NASA).

In addition, vigorous cooperative activities under the U.S.-Japan Conference on Development and Utilization of Natural Resources (UJNR) which was established in 1964, have been conducted for 30 years and in 18 fields by each special sub-committee.

Further, cooperation in the area of science and technology is being encouraged in a wider range through the Japan-U.S. Conference on Development and Utilization of Natural Resources (UJNR), Japan-U.S. Cooperation Agreement on Nuclear Energy and Japan-U.S. Committee on Scientific Cooperation, etc.

Cooperation under the framework of the U.S.-Japan Economic Framework Talks agreed to establish at the Japan-United States summit of July 1993, is being undertaken regarding in addition to macro-economic field and structural field by the sector such as automobile, global-scale subjects in which Japan and the U.S. should lead the world in tackling, such as technology, environment, population, and AIDS. In the same vein of "Cooperation in Global Perspective," concrete results have been attained, such as the conclusion of the implementing arrangement on cooperation regarding the civil industrial technology, and the promotion of a the Global Observation Information Network (GOIN). In addition, the plan of action of the " Access to Technology" has been considered for the purpose of expanding the distribution of people as well as information in science and technology fields between Japan and the U.S. at conferences in structural field by the sector.

In June 1991, the new Japan-France Science and Technology Cooperation Agreement, a revision of the old agreement concluded in 1974, was concluded in order to advance further scientific and technological cooperation between both countries. The agreement was revised because of recent progress in science and technology made in both countries. Under the new agreement, three types of meetings will be held: a meeting of high-level representatives at the cabinet level, a joint working committee of concerned experts and a joint committee of business people working in the field. At the 2nd meeting of high-level representatives in May 1994, participants exchanged opinions about the future of science and technology cooperation between the two countries. Further, in September 1994, a Japan-France Science and Technology Symposium was held with an aim to increase both countries' understanding of the state of science and technology, and to seek out possibilities for future cooperation. Opinions were exchanged freely between participants drawn from industry, universities and national research institutes.

Concerning the Cooperation with Canada, the Japan-Canada Science and Technology consultation began in 1972. This was superseded by the Japan-Canada Science and Technology Cooperation Agreement to further strengthen bilateral cooperation in science and technology, which was signed in May 1986. In April 1989, a Japan-Canada Space Panel was established to exchange of opinions and information regarding cooperation in areas of space development.

In July 1989, the Report on Japan-Canada Complementary Study was completed by experts of both countries to explore the priorities for future scientific and technological cooperation. Based on this study, cooperative activities have been promoted through bilateral workshop program in which researchers from both countries can discuss and exchange views on specific research theme.

Further, the "Japan-Canada Forum 2000" report, initiated by an agreement reached at the Japan-Canada summit in May 1991, was submitted to prime ministers of both countries in December 1992. The report advised cooperation between the two countries on environmental problems in the North Pacific. A symposium held in Vancouver in March 1994 attended by experts on the environment from both countries. In addition, in February 1995, a Northern Pacific Earth Science and Environment Panel, which conducts exchanges of opinions and information between the two countries, was established under the Japan-Canada Science and Technology Cooperation Agreement.

Japan and Germany cooperate in the areas of nuclear energy, life sciences, ocean science and technology, etc. based on the Japan-Germany Science and Technology Cooperation Agreement concluded in October 1974 between Japan and West Germany. After the integration of East and West Germanies in October 1990, the

Agreement was confirmed to be effective under the entire territory of integrated Germany. At the 15th Japan-Germany Science and Technology Joint Committee meeting held in March 1994, science and technology policies of each country were introduced, and ideas for concrete cooperative projects were discussed.

As for cooperation with the United Kingdom, Japan-United Kingdom Science and Technology Cooperation meetings have been held for three times. However, in order to reinforce science and technology cooperation between the countries further, agreement between the government of the United Kingdom of Great Britain and Northern Ireland and the government of Japan on cooperation in science and technology was concluded in June 1994.

Japan has concluded science and technology cooperation agreements with Italy and cooperative activities in a variety of fields are underway based on these agreements. Cooperation with other countries is also underway through working-level staff activities, including the Japanese-Finish Meeting on Cooperation in Science and Technology and the Japanese-Swiss Meeting on Cooperation in Science and Technology, as well as through Trade and Economic Consultations with Sweden and Norway.

The Japan-EU Ministerial Meeting and the Japan-EU High Level Consultation have also been taking up issues for science and technology cooperation. In June 1994, Japan-EU Forum on Science and Technology Cooperation was held with the purpose of promoting cooperation on science and technology between the two parties.

3.4.4.1.2 Cooperation with Asian and Pacific Rim countries

Based on the Japan-Republic of Korea Science and Technology Cooperation Agreement concluded in December 1985, Japan is cooperating with South Korea in such fields as ocean science, resources and energy. And also cooperation in science and technology is currently being discussed under the first conference of Japan-South Korea New Initiative for Economic Partnership held in April 1994 and the second conference in October 1994, which conducts comprehensive discussions on cooperative relationships in bilateral economic areas. This conference is based on the results of the Japan-South Korea summits of March 1994.

Japan is also cooperating with China based on the Japan-China Science and Technology Cooperation Agreement concluded in May 1980 in carrying out information exchanges, exchanges of specialists and joint research with the aim of promoting cooperation in the fields of science and technology. The two countries have established a Japan-China Science and Technology Cooperation Committee to further advance cooperation. Further, meetings at the vice-minister level have been set up between Japan's Science and Technology Agency and China's State Science and Technology Commission, at which cooperation between the two countries has been discussed.

In addition, Japan is cooperating with Australia, Indonesia, India and Brazil in various fields on the basis of science and technology cooperation agreements. A Science and Technology Cooperation Agreement was also concluded with Israel in December 1994. In addition, Japan is cooperating with the nations of Asia and the Pacific Rim, both in multilateral and bilateral forms of cooperation, under the terms of the Asia-Pacific Economic Cooperation (APEC) and the Association for Science Cooperation in Asia (ASCA).

3.4.4.1.3 Cooperation with the Former Soviet Union and Central and Eastern European Countries

Cooperation with the Former Soviet Union (FSU) has been promoted based on the Japan-U.S.S.R. Agreement on Cooperation in Science and Technology, concluded in October 1973. Under this agreement, seven Japan-U.S.S.R joint committees and two joint committees with Russia have been formed. Cooperation has been promoted in the form of exchange of information and researchers, holding seminars, etc. in the fields of earth science, agriculture and forestry, etc.

In addition to the above, investigator exchanges have increased under the Japan-U.S.S.R. Researcher Exchange Arrangement.

Although the U.S.S.R. collapsed at the end of 1991, the Japan-U.S.S.R. Agreement on Cooperation in Science and Technology, etc. is effective with Russia since it has taken over the same authority.

At the second meeting of the Japan-Russia Science and Technology Cooperation Committee held in May 1994, agreement was reached to continue and expand cooperation in the fields agreed upon at the previous 7th Japan-Russia Science and Technology Cooperation Committee. Also, the two countries agreed to start cooperation in the three fields of basic chemistry, material science and technology, and biotechnology.

Japan has been cooperating with the Central and East European countries through exchange of researchers, etc. according to science and technology cooperation agreements with Poland and Yugoslavia and science and technology cooperation arrangements with Romania, Bulgaria, Czechoslovakia and Hungary (former Yugoslavia has collapsed as a nation, and the agreement with former Yugoslavia has been succeeded with Croatia and Slovenia).

The former state of Czechoslovakia has separated into The Czech Republic and The Slovak Republic. Both two countries succeeded to the agreement with Japan.

The Second Intergovernmental Consultation on Cooperation in the Field of Science and Technology between Japan and the Republic of Hungary was held in September 1994. Opinions were exchanged regarding themes for cooperation under a Japan-Hungary arrangement concerning science and technology cooperation, as well as both countries'science and technology policies.

In September 1994, the preparation meetings of the Intergovernmental Consultation on Cooperation in the Field of Science and Technology between Japan and the Republic of Poland were held to discuss ways for Japan and Poland to promote science and technology cooperation. The Japan-Central Europe Joint Workshop on Advanced Computing in Engineering was held in September 1994 in order to activate research exchanges between Japan and central European countries, and to advance the progress of Japan's own computing science fields.

3.4.4.2 Multilateral Cooperation

3.4.4.2.1 International Cooperation Based on the Economic Summit of the Heads of State or Government of Seven Major Industrial Nations and the President of the Commission of the European Communities

The leaders of the industrialized nations have been discussing science and technology issues at Summits every year since French President Mitterand first raised the subject at the 8th Summit at Versailles in June 1982.

In 1989, the Arch Summit initiated cooperation in global environmental problems which have become of increasing concern in recent years. Further efforts were required in expanding global observation and monitoring activities, performing scientific surveys about the global weather conditions, and developing and disseminating energy and environmental technology.

In July 1992, at the Munich Summit, various countries requested that the seven advanced nations of the world take action about global environmental problems. In terms of the issue of scientists and engineers leaking intelligence out of the former U.S.S.R., it was confirmed that an International Science and Technology Center would be established to support the employment of scientists and engineers who had been involved in the production of weapons of mass destruction in work for peaceful objectives.

At the Tokyo Summit in July 1993, the necessity of countries cooperating to support nuclear non-proliferation and increase the safety of nuclear power stations in the former U.S.S.R. was reconfirmed. Also, it was declared that among the policies of the seven advanced nations, global environmental problems would continue to be given highest priority.

At the July 1994 Naples Summit, political matters such as regional disputes and the reinforcement of nuclear non-proliferation, and economic matters such as the problem of nuclear power safety in the Ukraine and other parts of the former Soviet Union, and other countries in Middle and Eastern Europe, and employment and growth were discussed. As a result, technological innovation and the proliferation of new technologies, as well as support for nuclear safety were adopted in the chairman's declaration, which advocated the extension of the Nuclear Non-Proliferation Treaty and the economic declaration, which included the establishment of a world information infrastructure.

3.4.4.2.2 Cooperation with the United Nations

United Nations committees and organizations are addressing important issues related to natural resources, energy, food, climate, environment and natural disasters, since these problems require solutions derived from a global perspective.

They are making an effort to contribute to a long-term solution of the North-South problem by strengthening the science and technology capabilities of developing nations as these nations suffer the most from the above-mentioned problems.

The United Nations Conference on Environment and Development (UNCED: Global Summit) was held in Rio de Janeiro.

Participants from about 180 nations attended against the backdrop of the increasing worldwide interest in global environment problems in recent years. The Global Summit produced abundant results: over 150 nations signed the "Rio Declaration on Environment and Development" which provided the action principles for nations and individuals in preparation for the 21st century, "Agenda 21" and "Declaration on Forest Principles", which comprised concrete action plans for this Rio Declaration, and the "Framework Treaty on Climate Variations" and "Biological Diversity Treaty". Follow-up discussions to the Global Summit took place at the 47th United Nations General Assembly, and resolutions were passed to establish a "Sustainable Development Committee" and a "Government Negotiating Committee to Formulate a Treaty to Prevent the Spread of Deserts".

Based on these United Nations resolutions, the "Sustainable Development Committee" was established in February 1993, and held its first meeting in June of that year. and second meeting in May 1994. In veiw of the worldwide increasing interest in global environment problems in recent years, the United Nations Conference on Environment and Development(UNCED:Global Summit) was held in Rio de Janeiro in June 1992 and participants from about 180 nations was attended. The Global Summit produced many results:the "Rio Declaration on Environment and Development" which provided the action principles for nations and individuals in preparation for the 21st century,"Agenda 21" and "Statement on Forest Principles",which comprised concrete action plans for Rio Declaration, and over 150 nations signed the "Framework Convention on Climate Change" and "Convention on Biological Diversity". Follow-up to the Global Summit was discussed at the 47th United Nations General Assembly,and resolutions were passed to establish the "Committee on Sustainable Development" and the "Intergovernmental Negotiating Committee for a Convention to Combat Desertification"

Based on these United Nations reolutions, the "Committee on Sustainable Development" was established in February 1993, and the first, second and third sessions were held in June of the same year, May 1994 and April 1995 respectively. In addition, the "Convention to Combat Desertification" was adopted along with the Resolution Regarding Provisional Measures to be Taken until the Treaty Goes into Effect, and the Resolution Regarding Emergency Action for Africa. In October 1994, representatives from 86 countries, including Japan and the EU, were present to sign the treaty.

3.4.4.2.3 Cooperation within the Organization for Economic Cooperation and Development

Cooperation in science and technology related activities within the Organization for Economic Cooperation and Development (OECD) framework has been conducted through the Committee for Scientific and Technological Policy (CSTP), Committee for Information, Computer and Communications Policy (ICCP), Industry Committee, Environment Committee, Nuclear Energy Agency (NEA), International Energy Agency (IEA). Activities include exchanging opinions, useful experiences, information and personnel, compiling of statistical information and being involved in joint research projects.

The Megascience Forum was established in 1992 by CSTP, views and information regarding megascience projects from its initial stages are exchanged among governmental officials and scientists in order to achieve common awareness regarding the future of international cooperation in megascience. In addition to six main meetings held thus far, expert meetings have been held to review developments in individual areas such as astronomy, deep earth drilling, global change research, oceanographic science, radiation and neutron sources, and particle physics.

In addition, the Science System Group was established in 1993 by CSTP in order to understand the future of international scientific cooperation which will follow changes in the international situation such as the unification of Europe and the strengthening of alliances in North America and the Pacific Rim, and to discuss the influence of these changes on the scientific systems in each country and policies on how to utilize this influence effectively. The group held four meetings thus far. Further, The Working Group on Innovation and Technology Policy was established in 1993 byCSTP, for the purposes of conducting discussions aimed at enhansing the mechanisms for utilizing scientific and technical output to increase productivity and employment, and on promoting international technology cooperation, at avoiding "technological friction" caused by the interdependence of the innovation process and the internationalization of science and technology, and at achieving international harmony in connection with technology policy. The group held four meetings thus far.

At the March 1994 G7 Jobs' conference in Detroit, U.S., agreement was reached and at the OECD, research on Technology, Productivity and Employment is being advanced mainly by a joint specialist's conference formed by the CSTP, the Industry Committee and the Information and Computer Policy Committee. Their final report is to be submitted to the OECD Board of Ministers in 1996.

3.4.4.2.4 Promotion of the Human Frontier Science Program

The Human Frontier Science Program (HFSP) is an international program which promotes, through international cooperation, basic research focused on the elucidation of the sophisticated and complex mechanisms of living organisms. The Japanese government proposed the program at the Venice Economic Summit in June 1987, as a means for the government to contribute to the development of international science and technology in a manner appropriate to its economic standing. The HFSP also can help to increase international public assets through the promotion of basic research and to make the research results available to all humankind.

The program and the Japanese initiative behind it have been lauded by the Economic Summit member countries. In October 1989, the organization for the implementation of the HFSP, the International HFSP Organization (HFSPO), was established in Strasbourg, France.

The Program offers support for the following activities. Workshops: Subsidies for international research meetings (workshops)

- Research grants: Subsidies for international joint research teams
- Long-term and short-term fellowships: Travel and accommodation subsidies for researchers who wish to do research in foreign countries
- Workshops: Subsidies for international workshops

The fields eligible for support fall into two basic research areas — the elucidation of brain functions and the elucidation of biological functions through a molecular level approach. On the basis of recommendations by the International Scientific Committee, consisting of eminent scientists, these research areas were agreed to by the countries concerned.

On January 1992, government representatives of countries which support the HFSP agreed to continue the program on a full phase after April 1992.

The HFSPO reported in March 1994 that 333 researchers had been selected as the award recipients for the fifth fiscal year.

As for the future of the HFSPO, an evaluation of the effectiveness of the program from a scientific standpoint is to be conducted roughly five years after the establishment of the HFSPO through meetings between governments of the HFSP countries. A principal review of the program as a whole will be implemented by the end of March 1996, and will be reported to the countries providing operations and assistance as a basis for discussions regarding the future of the program.

3.4.4.2.5 Cooperation under the Association for Science Cooperation in Asia (ASCA)

In November 1970, agreement was reached on the establishment of ASCA. With the aim of exchanging information on science and technology policies and research and development plans in Asia, shedding light on areas of common interest, and investigating and strengthening policies for the promotion of international science and technology cooperation projects within the region, ASCA has met 13 times to bring together the ministers in charge of science and technology from each nation. At the 13th meeting held in November 1994 in Manila, members debated the alternate holding of minister-level and high-level meetings and the future direction of ASCA activities. Japan recognizes the need to further activities centered around the strengthening of the development of human resources in science and technology and the maintenance of a research information base, and has proposed expanding the STA Fellowship Program, holding seminars for R&D managers, and forming working groups and expert meetings for the purpose of encouraging the circulation of scientific and technological information. In addition to sending a representative to each meeting, Japan has conducted seminars focusing on areas of high interest to the countries of ASCA. In March 1994, Japan held the "ASCA Seminar on Utilization and Regulation of Microorganisms in Asia", and the "ASCA Seminar on Science,Technology and Regional Technological Innovation". Since 1980, Japan has been implementing ASCA science and technology information cooperation projects that provide information on science and technology from Japan to the other members of ASCA.

3.4.4.2.6 Cooperation under the Asia-Pacific Economic Cooperation (APEC)

As a place of conference among the goverments for economic cooperation in the Asia-Pacific region, the Asia-Pacific Economic Cooperation (APEC) was established in 1989. Aiming general cooperation, it has promoted mainly economic and technological cooperation such as free trade and investment, and the development of human resources. In recent years, APEC has been vigorously active in trying to strengthen its functions. At the Sixth Council of

Ministers meeting held in Jakarta, an Economic Committee was established, and continuing from the previous year, in addition to the Council of Ministers, unofficial summit meetings were held.

10 working groups have been established to discuss concrete cooperative policies in senior official meetings in areas such as trade and investment data review, promotion of trade, industrial science and technology, development of human resources, regional energy cooperation and telecommunications. In particular, the industrial science and technology working group is conducting discussions on various cooperative measures, such as the establishment of scientific and technological indicators and the holding of R&D symposiums.

In addition, the holding of a meeting of cabinet ministers in charge of science and technology proposed by China at the recent un-official top-level meeting in November 1994 was accepted at the APEC high-ranking working level meeting in February 1995. Japan is preparing for the holding of this meeting based on its recognition of the importance of striving to build on scientific and technological cooperation in the Asia-Pacific region.

3.4.4.2.7 Cooperation under the Pacific Economic Cooperation Committe

The Pacific Economic Cooperation Committee (PECC) is an international organization established with the goal of promoting cooperation that will lead to the economic prosperity and stability in the Asia-Pacific region, and is characterized by a tripartite structure comprised by government, business world and academic world. Since the first general meeting of PECC in Canberra, Australia in September 1980, discussions on cooperation in a number of areas including trade policy, energy problems, technology transfer and capital transfer have been carried out. At present, discussions are being conducted in small committees on regional cooperation policies in a variety of areas, including trade policy; transportation, communication and tourism; mineral products and energy; science and technology; and the cultivation of human resources. At the 10th general meeting held in Kuala Lumpur, Malaysia, in March 1994, the Kuala Lumpur Concord was adopted, confirming the importance of the region in which PECC meetings are held.

In Japan, the Science and Technology Japan Small Committee is carrying out cooperation including the promotion of studies, analysis and research regarding problems associated with science and technology transfer, the establishment and maintenance of scientific and technical indicators and the cultivation of human resources.

3.4.4.2.8 Cooperation under the International Science and Technology Center (ISTC)

In November 1992, Japan, the United States, the European Community and the Russian Federation signed an agreement to set up the International Science and Technology Center (ISTC) in order to provide an opportunity for former-U.S.S.R. scientists and engineers with expertise in the area of weapons of mass destruction to steer their talents toward peaceful activities, and to help contribute to the resolution of domestic issues faced by the former-U.S.S.R. as well as issues faced by the international community. The ISTC was founded in March 1994 through the signing in December 1993 of a protocol allowing for the provisional application of the agreement. At the five meetings of the Board of Directors held thus far, a total of $60.6 million toward the initiation of 130 specific activities for the purpose of achieving the center's goals was approved.

Japan intends to actively contribute personnel and use its past experiences toward cooperation in future endeavors. Japan will continue to strive to see that the activities of this center are implemented smoothly and developed effectively.

Since establishment of the center, Finland, Georgia, Sweden, Armenia and Belarus have completed their entrance procedures, and Kazakhstan and Kirghiztan are expected to participate in the near future.

3.4.4.3 Promoting International Research Exchange

For many years, Japan has been cooperating with other countries in a wide range of fields within the framework of bilateral and multilateral scientific and technological cooperation agreements. However, Japan needs to extend its international research exchange to meet worldwide expectations regarding the nation's role and to stimulate Japanese science and technology within the context of international cooperation.

Since FY1987, the government has carried out the bilateral international joint research within the framework of bilateral science and technology cooperation agreements, by using the Special Coordination Funds for Promoting Science and Technology. To promote effectively international research exchanges in important areas of cooperation in view of policy issues related to science and technology cooperation agreements, etc. the government started in 1991 the International Workshops Support Program to hold international workshops in which researchers may exchange opinions directly.

In FY1993, taking a global perspective in terms of issues that need to be addressed in the wide geographical region of which it is part, Japan built a network of people and information, established a global research network to conduct joint research and initiated "global science and technology cooperation" as the theme for the first year.

In FY1988, to further promote the existing exchange programs among researchers.

- The Science and Technology Agency Fellowship Program, which provides for the acceptance of young researchers from overseas at the national research institutes
- The Japan Society for the Promotion of Science (JSPS) Fellowship for Research in Japan, which provides for the acceptance of overseas researchers at Japanese academic institutions
- The Foreign Researcher Invitation Program of the Agency of Industrial Science and Technology (AIST), which provides for the acceptance of overseas researchers in its research institutes
- Inviting of researchers as an operation of Institute for Transfer of Industrial Technology
- JIRCAS Fellowship Program of Japan International Research Center for Agricultural Sciences, Ministry of Agriculture, Forestry and Fisheries.

In October 1989, the Research Development Corporation of Japan (JRDC) started the following new programs to promote international research exchanges.

- Administration of the Science and Technology Agency Fellowship Program.
- International Joint Research Program, which initiates joint research with overseas research organizations.
- The Support Program, which includes operating dormitory facilities and providing practical assistance for overseas researchers and their families.
- Constructing of facilities for international research exchange.
- Research Cooperation Promotion Program which send researchers from national research institutes to Asian Pacific countries to promote research cooperation and exchange.
- The Research Information Program, which disseminates scientific and technological information required to increase the exchange.

In addition, other ministries and agencies have taken measures to promote international research cooperation.

3.4.5 Principal R&D Programs

Following paragraphs summarize important

R&D programs by government ministries and agencies.

(1) Science and Technology Agency

The Special Coordination Funds for Promoting Science and Technology were first appropriated in FY1981, superseding the previous Special Coordination Funds for Promoting Research. In accordance with the policy set forth by the CST, the funds are intended to support comprehensive coordination of R&D promotion. For example, the funds are used for comprehensive R&D which cuts across the boundaries of existing research organizations.

The funds are administered on the basis of the following six guiding principles.

- Promoting advanced and basic/generic research
- Promoting R&D requiring cooperation among several research institutes
- Strengthening organic ties among industry, the government and academia
- Promoting international collaborative research projects
- Responding flexibly to urgent research needs
- Conducting research evaluation, as well as investigation and analysis of research and development

This coordination fund provides for general research, Center of Excellence (COE), ministerial based research, research on lifestyles and regional trends, research on priority areas of international exchange, international joint research in areas of individual importance, basic research on priority areas, surveys and analyses, urgent research, studies and research on the maintenance, operation and utilization of a government research network which connects domestic and international research institutions, along with studies and research on the creation of a data base of basic and fundamental data. In addition, from FY1995, the STA will promote a Basic Research for Life and Society (reorganization of joint research utilizing science and technology potential in region) which comprehensively promotes goal-directed research which contributes to the improvement of quality of life and to regional development, and a Priority Research Assistance Cooperative Member Program directed at the establishment of a suitable research assistance system. The Special Coordination Fund for FY 1995 amounted to ¥18.5 billion.

Special Funds for Investigation and Research of Earth Science and Technology was initiated in FY1989 in order to conduct research to explain global phenomena. The budget for this research in FY1995 was 800 million yen.

For Japan to establish itself as a mature science and technology-based nation, it needs to discover the scientific and technological seeds that become the starting points for the original development of innovative new technologies.

In FY1981, this consideration led the Research Development Corporation of Japan to set up the Exploratory Research for Advanced Technology (ERATO) Program to provide for comprehensive research promotion organized around the most creative people. This is accomplished by appointing distinguished scientists as overall managers with administrative authority over research activities within a designated area of research in a humanistic system which utilizes creativity. It also provides for the procurement of researchers from industry, government, academia and overseas.

Currently, 24 projects are underway with budgetstotaling 7.8 billion yen in FY1995. Each project has a limited duration of five years and involves approximately 20 researchers.

The Precursory Research for Embryonic Science and Technology (21 pioneering project) System, set up by its parent organization, the Research Development Corporation of Japan, in 1991, recruits researchers from throughout Japan, selects the top researchers with the most creative ideas and let's the individuals freely conduct their research for a certain period. In FY 1995, research is being conducted on 66 topics in six existing regions and on 30 new topics with a budget of ¥1.9 billion.

The Institute of Physical and Chemical Research (RIKEN) initiated the Frontier Research Program in FY1986. This internationally open program brings together researchers in many fields outside the framework of existing research organizations. The program aims at developing new knowledge that will become the foundation for technological innovations in the next century.

Currently, there are three groups active as international frontier research program and two groups active as regional frontier research program. The budget for FY1995 is 3.9 billion yen.

(2) Environmental Agency

In the Environmental Agency, the national agency disaster prevention funds and testing and research funds are being used to implement research on disaster prevention at national research institutes, along with research on the preservation and maintenance of the natural environment. The amount of these budgets for FY1995 is 1.9 billion yen. In addition, In FY1990, the Environmental Agency set up the Comprehensive Promotion Fund for the Promotion of Global Environmental Research to bring together researchers from national testing and research organizations as well as universities and other organizations to promote global environmental research. The budget for this promotion fund was 2.5 billion yen in FY1995.

(3) Ministry of Health and Welfare

In FY1979, the Ministry of Health and Welfare established the Research Grant for Health Sciences to promote research in the areas of health, medical care, sanitation, etc., and had budgets of 11.4 billion yen in FY1995.

(4) Ministry of Agriculture, Forestry and Fisheries

In 1978, the Ministry of Agriculture, Forestries and Fisheries began to implement separate large-scale research to combine the research and development strength of industry, universities and the Government and conduct large-scale research and development. In 1984, the Ministry started to conduct research and development on leading biotechnology in order to promote research related to agriculture, forestries and fisheries. In addition, the Ministry is also conducting comprehensive research and development and separate general research. The budget for these in FY1995 were 1.3 billion yen, 2.8 billion yen, 1.3 billion yen and 600 million yen (total of 5.8 billion yen), respectively.

(5) Ministry of International Trade and Industry

In FY1993, the Ministry of International Trade and Industry integrated the National Research and Development Program (Large-scale Project), Research and Development Program on Basic Technologies for Future Industries, and National Research and Development Programs for Medical and Welfare Apparatuses to form the Industrial Science and Technology Frontier Program. This system conducts research and development that emphasizes basic, creative areas as well as public, social and welfare areas and implements leading research in the areas of pre-project research and basic research and survey. The budget for this system was 26.0 billion yen in FY1995.

In FY1993, the Ministry integrated the former new energy technology (Sunshine Plan), energy conservation technology Moonlight Plan), and global environmental technology research and development structures and established the Comprehensive Research and Technology Program on Energy and Environmental Technologies (New Sunshine Plan). The budget for this plan was 54.2 billion in FY1995.

(6) Ministry of Transport

In 1982, the Ministry of Transport began to conduct an investigation on R&D of transport technology in regards to topics which need to be carried out with emphasis and urgency and integrated in many research areas. The budget for this investigation in FY1995 was 300 million yen.

(7) Ministry of Posts and Telecommunications

Since FY1988, the Ministry of Posts and Telemunications has been conducting Research on the Frontier of Telecommunications. The program consists of basic and leading R&D that incur high financial risks and long-term commitments far beyond the capacity of the private-sector. The budget for this program in FY1995 was 900 million yen.

(8) Ministry of Construction

The Ministry of Construction has been implementing since 1972 its Comprehensive Technological Development Project for those issues of urgent need which cover wide-ranging areas of R&D. This program had budgets of 1 billion yen in FY1995.

APPENDIX

Appendix

1. Changes in R&D expenditures, etc. in Japan
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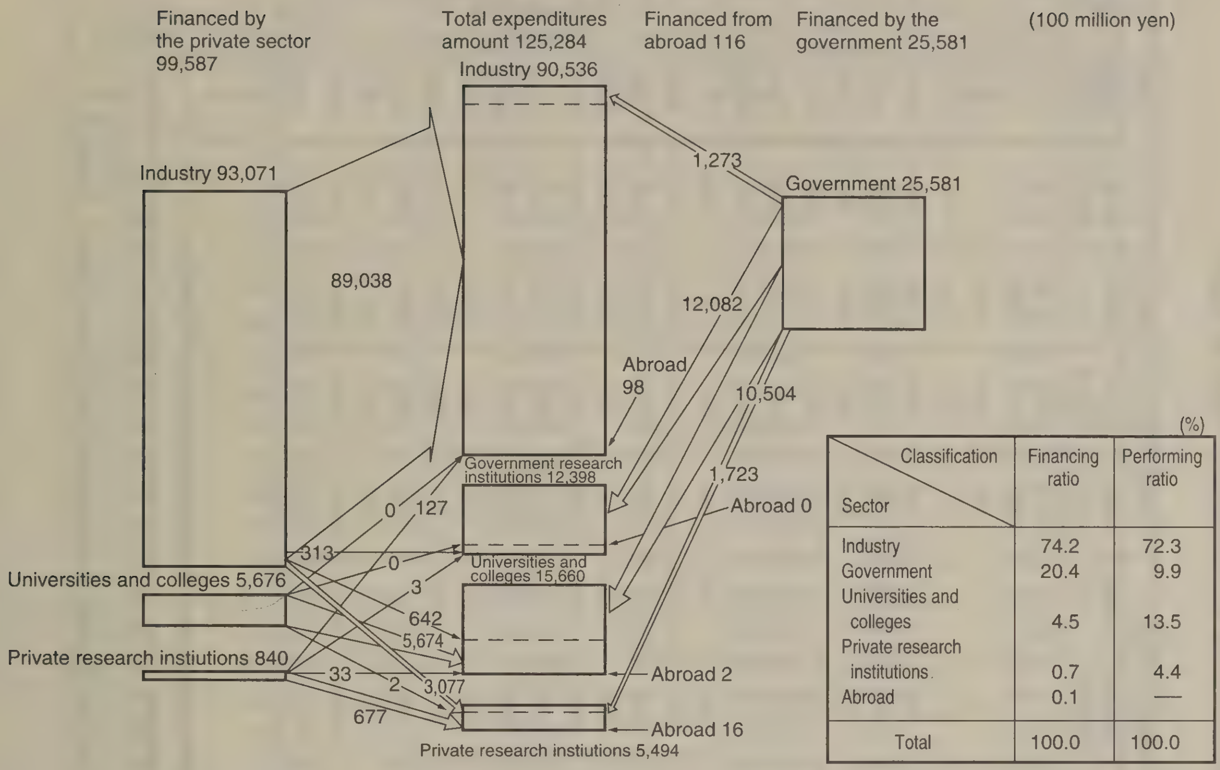
1. Changes in R&D expenditures, etc. in Japan

Fiscal Year \ Item	Gross national product	Gross domestic product	National income	R&D expenditures	Government financed R&D expenditures	Defense-related R&D expenditures	A	B	C	D	E	Number of researchers	Population
	Trillion yen	Trillion yen	Trillion yen	100 Million yen	100 Million yen	100 Million yen	%	%	%	%	%	Persons	10 Thousand Persons
1971	82.8063	82.8993	65.9105	15,323.72	4,473.88	123.05	1.85	1.85	2.32	29.2	28.6	242,155	10,610.0
72	96.5391	96.4863	77.9369	17,918.71	5,188.41	140.96	1.86	1.86	2.30	29.0	28.4	247,309	10,759.5
73	116.6792	116.7150	95.8396	22,158.36	6,261.39	155.75	1.90	1.90	2.31	28.3	27.7	279,186	10,910.4
74	138.1558	138.4511	112.4716	27,160.32	7,832.41	161.56	1.97	1.96	2.41	28.8	28.4	292,097	11,057.3
75	152.2094	152.3616	123.9907	29,745.73	8,829.04	169.49	1.95	1.95	2.40	29.7	29.3	310,111	11,194.0
76	171.1525	171.2934	140.3972	33,206.85	9,764.86	188.25	1.94	1.94	2.37	29.4	29.0	316,860	11,309.4
77	190.0348	190.0945	155.7032	36,513.19	10,788.11	218.26	1.92	1.92	2.35	29.5	29.1	329,447	11,416.5
78	208.7809	208.6022	171.7785	40,458.64	12,191.72	242.72	1.94	1.94	2.36	30.1	29.7	331,467	11,519.0
79	225.4018	225.2372	182.2066	45,836.30	13,534.16	276.49	2.03	2.04	2.52	29.5	29.1	341,488	11,615.5
80	245.3600	245.5466	199.5902	52,462.48	14,650.26	295.99	2.14	2.14	2.63	27.9	27.5	363,534	11,706.0
81	260.3343	260.8013	209.7489	59,823.56	16,124.28	325.73	2.30	2.29	2.85	27.0	26.6	379,045	11,790.2
82	273.4615	273.3224	219.3918	65,287.00	16,661.64	364.87	2.39	2.39	2.98	25.5	25.1	392,625	11,872.8
83	285.9973	285.5934	230.8057	71,807.82	17,214.33	394.52	2.51	2.51	3.11	24.0	23.6	406,042	11,953.6
84	305.7253	305.1441	243.6089	78,939.31	17,777.80	446.07	2.58	2.59	3.24	22.5	22.1	435,340	12,030.5
85	325.3705	324.1590	259.5898	88,902.99	18,672.53	586.77	2.73	2.74	3.42	21.0	20.5	447,719	12,104.9
86	339.6853	338.3527	269.3947	91,929.32	19,553.11	661.33	2.71	2.72	3.41	21.3	20.7	473,296	12,166.0
87	356.2636	353.9891	281.7375	98,366.40	21,118.40	741.35	2.76	2.78	3.49	21.5	20.9	487,779	12,223.9
88	379.2300	376.8886	299.5894	106,275.72	21,177.81	827.00	2.80	2.82	3.55	19.9	19.3	513,267	12,274.5
89	405.8039	402.3113	320.2186	118,154.82	22,024.20	930.68	2.91	2.94	3.69	18.6	18.0	535,008	12,320.5
90	435.3616	432.5885	342.8725	130,783.15	23,465.62	1,042.68	3.00	3.02	3.81	17.9	17.3	560,276	12,361.1
91	459.0454	455.8881	359.8071	137,715.24	25,044.63	1,150.45	3.00	3.02	3.83	18.2	17.5	582,815	12,404.3
92	468.8768	464.1914	361.0000	139,094.93	26,967.17	1,269.89	2.97	3.00	3.85	19.4	18.6	598,333	12,445.2
93	470.8497	466.7638	358.8945	137,091.39	29,658.49	1,371.75	2.91	2.94	3.82	21.6	20.8	622,410	12,476.4
94	—	—	—	—	—	—	—	—	—	—	—	641,083	12,503.4

Notes: 1. A=R&D expenditures as a percentage of gross national product, B=R&D expenditures as a percentage of gross domestic produce, C=R&D expenditures as a percentage of national income, D= the ratio of R&D expenditures financed by government and E=the ratio of R&D expenditures financed by government excluding defense R&D expenditures.
2. R&D expenditures and the number of researchers are the total of natural sciences, social sciences and humanities.
3. The number of researchers is as of April 1 in each year.
4. Defense-related R&D expenditures are appropriations to the Defense Agency in the science and technology budget of the government.
5. The numbers of population are those of national censuses and estimations as of October 1.

Sources: 1. Gross national product, gross domestic product and national income: “Annual Report of National Accounts” by Economic Planning Agency.
2. R&D expenditures, government-financed expenditures and the number of researchers: “Report on the Survey of Research and Development” by the Statistics Bureau, Management and Coordination Agency.
3. Population: “Population Estimation Material” by the Statistics Bureau, Management and Coordination Agency.

2. Flow of R&D expenditures in Japan (in FY1993)


Financed by the private sector 99,587
Total expenditures amount 125,284
Financed from abroad 116
Financed by the government 25,581
(100 million yen)
Industry 90,536
Industry 93,071
89,038
1,273
Government 25,581
12,082
Abroad 98
10,504
1,723
Abroad 0
Government research institutions 12,398
0
127
313
0
3
Universities and colleges 5,676
642
5,674
Universities and colleges 15,660
Private research instiutions 840
33
2
3,077
677
Abroad 2
Abroad 16
Private research instiutions 5,494
(%)

Sector \ Classification	Financing ratio	Performing ratio
Industry	74.2	72.3
Government	20.4	9.9
Universities and colleges	4.5	13.5
Private research institutions.	0.7	4.4
Abroad	0.1	—
Total	100.0	100.0

Notes: 1. R&D expenditures are for natural sciences only.

2. R&D expenditures are the funds spent by research institutions themselves for research. There are two concepts of R&D expenditures on a performing basis: disbursement and cost. Japan considers R&D expenditures to be disbursements. Disbursement includes expenditures on labor, materials, tangible fixed assets, and so on. In case of cost, it is computed by adding the depreciation of tangible fixed assets instead of expenditures on the tangible fixed assets.

3. Coverage of each sector is as follows:

(1) Financing sector

1) Industry: companies and public corporations whose major purpose is not in research activities

2) Government: national and local governments, national, local government-owned research institutions, research-centered public corporations, and national and public universities and colleges (including junior colleges)

3) Universities and colleges: private universities and colleges (including junior colleges)

4) Private research institutions: nonprofit private research institutions

(2) Performing sector

1) Industry: coverage is the same as in the financing sector

2) Government research institutions: national and local government-owned research institutions and research-centered public corporations

3) Universities and colleges: national public and private universities and colleges

4) Private research institutions: coverage is the same as in the financing sector

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

3. Changes in composition ratios of R&D expenditures by character of work in Japan

(%)

Classification / Fiscal Year	Industry			Government research institutions			Universities and colleges			Private research institutions			Total		
	Basic research	Applied research	Development	Basic research	Applied research	Development	Basic research	Applied research	Development	Basic research	Applied research	Development	Basic research	Applied research	Development
1971	9.1	25.9	65.0	19.6	33.5	47.0	—	—	—	22.2	36.4	41.4	—	—	—
72	8.1	22.3	69.6	15.0	32.5	52.4	—	—	—	22.5	57.0	20.5	—	—	—
73	6.7	19.5	73.8	15.6	29.0	55.4	—	—	—	16.4	53.4	30.1	—	—	—
74	6.3	19.4	74.3	16.5	38.2	45.3	75.4	18.5	6.1	7.2	16.4	76.4	15.0	21.7	63.3
75	5.2	19.1	75.8	15.8	34.3	49.9	70.9	21.6	7.5	6.5	21.1	72.4	14.2	21.5	64.3
76	5.0	18.6	76.3	18.1	34.6	47.3	56.4	38.2	5.3	9.7	26.6	63.7	16.6	24.7	58.8
77	4.7	19.6	75.7	18.1	35.5	46.5	57.4	37.0	5.7	13.5	30.0	56.5	16.2	25.1	58.7
78	4.6	18.2	77.1	18.5	34.9	46.6	57.3	37.3	5.4	12.2	61.6	26.2	16.6	25.1	58.4
79	4.6	19.5	75.9	18.9	37.1	44.0	55.2	38.1	6.7	14.5	63.8	21.7	15.5	25.9	58.7
80	5.0	19.5	75.5	15.8	39.3	44.9	55.8	37.0	7.2	12.6	46.0	41.4	14.5	25.4	60.0
81	5.2	21.8	73.0	14.2	32.2	53.6	55.8	36.3	8.0	9.9	36.7	53.3	13.9	25.7	60.4
82	5.5	21.9	72.6	14.3	31.8	53.9	54.9	37.6	7.4	8.5	33.1	58.4	14.1	25.9	60.1
83	5.7	22.0	72.3	13.9	30.7	55.4	54.9	36.9	8.3	9.2	31.4	59.4	14.0	25.4	60.6
84	5.6	22.0	72.4	13.9	29.9	56.2	54.9	36.6	8.5	11.1	31.7	57.2	13.6	25.1	61.3
85	5.9	21.9	72.1	13.0	28.5	58.4	54.2	37.4	8.4	10.6	33.5	55.9	12.9	25.0	62.2
86	6.1	21.6	72.3	13.6	27.3	59.1	54.2	37.4	8.4	14.1	27.8	58.1	13.3	24.4	62.3
87	6.6	21.7	71.7	14.6	28.3	57.1	54.2	37.4	8.4	18.3	20.8	60.9	14.0	24.3	61.7
88	6.6	21.7	71.7	13.5	26.8	59.7	52.8	38.5	8.7	18.0	22.3	59.8	13.3	24.3	62.4
89	6.4	21.5	72.2	13.1	27.3	59.6	53.2	38.1	8.7	19.7	22.5	57.8	12.8	23.9	63.2
90	6.4	21.8	71.8	14.2	28.6	57.3	52.9	38.4	8.7	18.7	22.7	58.5	12.6	24.2	63.2
91	6.8	22.2	71.1	14.5	29.3	56.2	52.8	38.4	8.8	19.2	26.2	54.6	12.9	24.7	62.4
92	6.9	22.1	71.1	16.5	27.6	55.9	52.7	38.6	8.7	17.4	20.2	62.5	13.5	24.4	62.1
93	6.7	21.4	71.9	18.6	26.9	54.5	52.3	38.7	9.0	20.5	20.3	59.2	14.3	24.1	61.6

Notes: 1. For natural science only

2. The composition ratios by character of work were not surveyed for universities and colleges before FY1973.

3. Figures of "Government research institutes", "universities and colleges" and "private research institutions" before FY1975 do not include values in the health field.

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

4. Changes in R&D expenditures by financing sector in Japan

(million yen)

Classification	Total		National and local governments		Private sector		Abroad	
Fiscal Year	R&D expenditures (A)	Ratio	Financing amount (B)	Ratio B/A	Financing amount (C)	Ratio C/A	Financing amount (D)	Ratio D/A
		%		%		%		%
1971	1,345,919	100	369,025	27.4	975,905	72.5	988	0.1
72	1,586,708	100	432,068	27.2	1,153,560	72.7	1,081	0.1
73	1,980,896	100	522,684	26.4	1,456,891	73.5	1,321	0.1
74	2,421,367	100	641,077	26.5	1,778,834	73.5	1,456	0.1
75	2,621,827	100	720,755	27.5	1,899,293	72.4	1,779	0.1
76	2,941,373	100	800,386	27.2	2,138,368	72.7	2,619	0.1
77	3,233,543	100	886,115	27.4	2,343,681	72.5	3,747	0.1
78	3,569,953	100	999,502	28.0	2,567,390	71.9	3,061	0.1
79	4,063,627	100	1,113,822	27.4	2,946,391	72.5	3,414	0.1
80	4,683,768	100	1,209,557	25.8	3,469,557	74.1	4,655	0.1
81	5,363,986	100	1,340,320	25.0	4,017,752	74.9	5,914	0.1
82	5,881,539	100	1,388,812	23.6	4,486,044	76.3	6,682	0.1
83	6,503,737	100	1,440,717	22.2	5,054,895	77.7	8,125	0.1
84	7,176,511	100	1,494,546	20.8	5,674,783	79.1	7,182	0.1
85	8,116,399	100	1,573,953	19.4	6,534,619	80.5	7,826	0.1
86	8,414,993	100	1,651,680	19.6	6,755,682	80.3	7,631	0.1
87	9,016,186	100	1,798,270	19.9	7,210,127	80.0	7,789	0.1
88	9,775,165	100	1,801,373	18.4	7,965,544	81.5	8,249	0.1
89	10,909,335	100	1,867,936	17.1	9,031,804	82.8	9,595	0.1
90	12,089,593	100	1,990,147	16.5	10,089,311	83.5	10,134	0.1
91	12,720,140	100	2,137,444	16.8	10,571,062	83.1	11,634	0.1
92	12,788,221	100	2,305,868	18.0	10,469,175	81.9	13,178	0.1
93	12,528,354	100	2,558,101	20.4	9,958,662	79.5	11,591	0.1

Notes: 1. R&D expenditures are for natural sciences only.
2. Including social sciences and humanities, B/A in FY1993 is 21.6%.

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

5. Changes in R&D expenditures by performing sector in Japan

(million yen)

Classification / Fiscal Year	Companies, etc.				Research Institutions						Universities and colleges					Toral (D)	
	Companies	Public corporations (a)	Total (A)	Ratio A/D	National	Local government owned	Private	Public corporations (b)	Total (B)	Ratio B/D	National	Public	Private	Total (C)	Ratio C/D		Ratio
				%						%					%		%
1971	845,790	49,230	895,020	66.5	58,035	63,920	18,721	59,790	200,466	14.9	143,129	18,593	88,710	250,433	18.6	1,345,919	100
72	985,925	59,002	1,044,928	65.9	68,018	72,145	19,424	93,298	252,885	15.9	158,872	19,922	110,102	288,896	18.2	1,586,708	100
73	1,238,444	63,483	1,301,927	65.7	82,266	90,645	24,320	123,509	320,740	16.2	187,809	23,466	146,954	358,229	18.1	1,980,896	100
74	1,524,114	64,939	1,589,053	65.6	102,996	110,142	74,727	99,208	387,073	16.0	245,135	27,052	173,054	445,241	18.4	2,421,367	100
75	1,616,121	68,726	1,684,847	64.3	117,596	111,460	72,684	118,959	420,699	16.0	284,293	29,574	202,414	516,281	19.7	2,621,827	100
76	1,808,210	74,021	1,882,231	64.0	123,403	118,222	84,867	144,997	471,489	16.0	317,986	31,877	237,790	587,654	20.0	2,941,373	100
77	2,019,851	89,649	2,109,500	65.2	140,618	132,141	71,013	150,573	494,345	15.3	351,945	35,745	242,007	629,698	19.5	3,233,543	100
78	2,194,252	96,750	2,291,002	64.2	155,684	137,285	82,447	190,917	566,333	15.9	399,275	35,676	277,667	712,618	20.0	3,569,953	100
79	2,559,917	104,995	2,664,913	65.6	177,704	150,877	76,119	216,331	621,032	15.3	434,641	39,081	303,960	777,683	19.1	4,063,627	100
80	3,032,145	110,111	3,142,256	67.1	185,372	165,966	122,533	243,742	717,612	15.3	461,765	41,374	320,761	823,900	17.6	4,683,768	100
81	3,517,034	112,759	3,629,793	67.7	191,956	177,702	213,394	265,783	848,834	15.8	505,040	45,516	334,803	885,359	16.5	5,363,986	100
82	3,917,089	121,929	4,039,018	68.7	195,747	177,766	244,198	276,599	894,310	15.2	529,884	47,081	371,245	984,211	16.1	5,881,539	100
83	4,435,361	124,766	4,560,127	70.1	200,863	178,222	248,087	288,082	915,254	14.1	561,246	49,491	417,620	1,028,356	15.8	6,503,737	100
84	5,114,631	22,003	5,136,634	71.6	208,062	185,658	274,987	307,396	976,102	13.6	585,463	52,182	426,130	1,063,775	14.8	7,176,511	100
85	5,913,942	26,005	5,939,947	73.2	227,454	193,052	316,461	364,074	1,101,041	13.6	589,212	56,310	429,888	1,075,410	13.2	8,116,399	100
86	6,105,886	14,277	6,120,163	72.7	236,700	193,568	360,436	382,261	1,172,966	13.9	610,800	57,532	453,532	1,121,864	13.3	8,414,993	100
87	6,480,897	13,370	6,494,268	72.0	297,419	201,313	398,324	415,283	1,312,340	14.6	659,914	61,932	487,733	1,209,579	13.4	9,016,186	100
88	7,202,873	16,446	7,219,318	73.9	262,093	208,552	411,511	434,140	1,316,296	13.5	675,343	61,927	502,281	1,239,551	12.7	9,775,165	100
89	8,217,138	16,682	8,233,820	75.5	273,061	226,075	441,818	422,930	1,363,884	12.5	705,507	74,274	531,850	1,311,631	12.0	10,909,335	100
90	9,246,003	21,163	9,267,166	76.7	307,316	252,734	475,391	380,637	1,416,079	11.7	754,426	85,349	566,572	1,406,347	11.6	12,089,593	100
91	9,716,195	26,853	9,743,048	76.6	310,096	265,849	505,077	435,237	1,516,259	11.9	783,564	83,387	593,882	1,460,833	11.5	12,720,140	100
92	9,541,757	18,928	9,560,685	74.8	360,870	266,255	543,439	490,931	1,661,495	13.0	846,905	94,844	624,293	1,566,041	12.2	12,788,221	100
93	9,028,186	25,422	9,053,608	72.3	407,322	283,691	549,434	548,760	1,789,207	14.3	946,353	97,935	641,251	1,685,538	13.5	12,528,354	100

Notes: 1. R&D expenditures are for natural sciences only.
2. Public corporations (a) are those which are operated on a self-paying basis and public corporations (b) are those which are not expected to operate on a self-paying basis.
3. In FY1974, research associations based on the Research Associations for Mining and Manufacturing Technology Law were rearranged from public corporations (b) into private research institutions.

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

6. Changes in composition ratios of R&D expenditures by constituent elements in Japan

(%)

Fiscal Year		1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Companies	Labor cost	43.3	43.5	42.1	40.7	41.3	41.4	40.7	39.4	38.8	38.7	41.1	43.8
	Materials cost	19.8	19.6	20.5	20.5	20.5	20.3	20.9	21.1	21.4	20.8	19.7	18.7
	Expenditure on tangible fixed assets	15.9	15.4	15.5	16.5	15.7	15.6	14.7	15.6	15.5	15.7	13.0	11.3
	Other expenses	20.9	21.4	22.0	22.4	22.5	22.8	23.8	23.8	24.4	24.9	26.2	26.2
	Total	100	100	100	100	100	100	100	100	100	100	100	100
Research institutions	Labor cost	34.8	35.3	35.4	33.1	33.2	30.7	32.5	32.6	34.2	33.4	31.8	30.3
	Materials cost	13.3	12.6	13.6	14.6	17.4	16.2	17.5	17.6	18.8	14.5	16.2	15.2
	Expenditure on tangible fixed assets	28.0	25.8	27.2	29.2	26.9	29.8	26.7	24.2	22.7	21.5	22.4	26.8
	Other expenses	23.9	26.3	23.9	23.0	22.4	23.3	23.3	25.6	24.3	30.6	29.6	27.6
	Total	100	100	100	100	100	100	100	100	100	100	100	100
Universities and colleges	Labor cost	57.8	57.1	59.3	60.4	61.0	59.8	61.0	60.3	61.0	61.9	61.1	58.8
	Materials cost	9.2	8.4	8.8	8.7	8.7	8.5	9.0	9.3	8.9	8.9	9.1	9.2
	Expenditure on tangible fixed assets	18.9	19.4	18.0	16.0	16.0	17.2	15.5	16.0	15.0	14.2	14.8	17.1
	Other expenses	14.0	15.2	14.0	14.9	14.3	14.5	14.5	14.5	15.0	15.1	15.1	15.0
	Total	100	100	100	100	100	100	100	100	100	100	100	100
Total	Labor cost	44.4	44.5	43.7	42.3	42.8	42.3	42.2	41.1	40.8	40.7	42.3	43.9
	Materials cost	17.1	16.9	17.8	18.1	18.5	18.1	18.9	19.3	19.6	18.7	17.9	16.9
	Expenditure on tangible fixed assets	18.2	17.5	17.5	18.1	17.3	17.9	16.4	16.7	16.3	16.2	14.5	14.3
	Other expenses	20.3	21.1	21.0	21.5	21.4	21.7	22.5	22.9	23.3	24.4	25.3	24.9
	Total	100	100	100	100	100	100	100	100	100	100	100	100

Note: For natural science only

Source: “Report on the Survey of Research and Development” by the statistics Bureau, Management and Coordination Agency.

7. Changes in number of personnel engaged in R&D activities in Japan

(person)

Year	Number of R&D performing institutions	Personnel engaged in R&D activities		Researchers		Assistant reseach workers		Technicians		Clerical and other supporting personnel	
			%		%		%		%		%
1971	18,935	429,348	100	194,347	45.3	80,194	18.7	93,581	21.8	61,226	14.3
72	15,753	426,935	100	198,084	46.4	82,308	19.3	86,149	20.2	60,394	14.1
73	13,253	459,239	100	226,604	49.3	80,720	17.6	88,857	19.3	63,058	13.7
74	11,614	468,060	100	238,179	50.9	79,400	17.0	87,516	18.7	62,965	13.5
75	14,445	491,296	100	255,202	51.9	81,934	16.7	90,648	18.5	63,512	12.9
76	14,552	487,999	100	260,250	53.3	79,245	16.2	89,089	18.3	59,415	12.2
77	13,693	492,288	100	271,956	55.2	73,794	15.0	86,698	17.6	59,840	12.2
78	17,289	486,777	100	273,102	56.1	72,479	14.9	83,321	17.1	57,875	11.9
79	16,269	496,032	100	281,920	56.8	72,988	14.7	82,163	16.6	58,961	11.9
80	19,618	521,119	100	302,585	58.1	73,918	14.2	85,882	16.5	58,734	11.3
81	19,103	548,312	100	317,487	57.9	79,889	14.6	89,326	16.3	61,610	11.2
82	18,026	567,235	100	329,728	58.1	83,592	14.7	90,072	15.9	63,843	11.3
83	17,214	587,182	100	342,237	58.3	86,630	14.8	92,224	15.7	66,091	11.3
84	19,367	627,814	100	370,045	58.9	92,826	14.8	96,109	15.3	68,834	11.0
85	16,663	646,299	100	381,282	59.0	97,263	15.0	98,267	15.2	69,487	10.8
86	16,263	676,023	100	405,554	60.0	98,493	14.6	100,850	14.9	71,126	10.5
87	15,449	691,822	100	418,337	60.5	99,569	14.4	101,492	14.7	72,424	10.5
88	16,100	715,337	100	441,876	61.8	98,499	13.8	101,960	14.3	73,002	10.2
89	16,657	740,438	100	461,634	62.3	98,846	13.3	104,497	14.1	75,461	10.2
90	16,625	769,696	100	484,346	62.9	103,077	13.4	103,192	13.4	79,081	10.3
91	15,792	803,733	100	504,966	62.8	103,093	12.8	112,596	14.0	83,078	10.3
92	16,084	812,985	100	518,869	63.8	104,017	12.8	107,050	13.2	83,049	10.2
93	16,367	840,511	100	541,139	64.4	103,944	12.4	107,110	12.7	88,318	10.5
94	14,242	846,829	100	558,307	65.9	96,101	11.3	102,380	12.1	90,041	10.6

Note: For natural science only and figures are as of April 1 in each year.
Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

8. Changes in number of researchers by sector in Japan

(person)

Classi-fica-tion / Year	Companies, etc.				Research Institutions						Universities and colleges					Toral (D)	
	Compa-nies	Public corpora-tions (a)	Total (A)	Ratio A/D	National	Local govern-ment owned	Private	Public corpora-tions (b)	Total (B)	Ratio B/D	National	Public	Private	Total (C)	Ratio C/D		Ratio
				%						%					%		%
1971	108,593	2,651	111,244	57.2	9,187	11,333	1,534	1,302	23,356	12.0	35,679	4,597	19,471	59,747	30.7	194,347	100
72	110,017	2,746	112,763	56.9	9,231	12,284	1,734	1,569	24,818	12.5	36,168	4,415	19,920	60,503	30.5	198,084	100
73	121,797	2,998	124,795	55.1	9,327	13,012	1,769	2,542	26,650	11.8	43,648	6,940	24,571	75,159	33.2	226,604	100
74	127,536	3,154	130,690	54.9	9,206	13,848	1,824	3,412	28,290	11.9	46,362	6,605	26,232	79,199	33.3	238,179	100
75	143,364	3,240	146,604	57.4	9,341	13,732	1,775	1,842	26,690	10.5	46,771	6,648	28,489	81,908	32.1	255,202	100
76	142,554	2,662	145,216	55.8	9,341	13,698	2,048	1,923	27,010	10.4	50,695	7,120	30,209	88,024	33.8	260,250	100
77	148,741	2,696	151,437	55.7	9,421	13,760	2,654	1,905	27,740	10.2	53,110	7,559	32,110	92,779	34.1	271,956	100
78	150,924	2,782	153,706	56.3	9,712	13,857	2,342	1,977	27,888	10.2	52,019	7,124	32,365	91,508	33.5	273,102	100
79	154,447	2,832	157,279	55.8	9,724	13,737	2,377	2,079	27,917	9.9	54,086	7,154	35,484	96,724	34.3	281,920	100
80	170,279	2,965	173,244	57.3	9,895	13,988	2,512	2,246	28,641	9.5	57,434	7,342	35,924	100,700	33.3	302,585	100
81	181,892	2,997	184,889	58.2	10,073	14,110	3,412	2,411	30,006	9.5	57,523	7,395	37,674	102,592	32.3	317,487	100
82	189,952	2,990	192,942	58.5	10,067	14,257	5,901	2,449	32,674	9.9	58,340	7,612	38,160	104,112	31.6	329,728	100
83	198,132	3,005	201,137	58.8	10,217	13,907	4,514	2,532	31,170	9.1	60,774	8,171	40,985	109,930	32.1	342,237	100
84	220,835	3,047	223,882	60.5	10,179	13,958	5,376	2,467	31,980	8.6	62,906	8,400	42,877	114,183	30.9	370,045	100
85	230,445	652	231,097	60.6	10,037	13,994	5,649	2,487	32,167	8.4	64,657	8,616	44,745	118,018	31.0	381,282	100
86	251,138	633	251,771	62.1	10,169	13,843	5,902	2,545	32,459	8.0	65,926	8,714	46,684	121,324	29.9	405,554	100
87	260,457	389	260,846	62.4	10,106	13,748	6,715	2,688	33,257	7.9	67,590	8,974	47,670	124,234	29.7	418,337	100
88	278,904	394	279,298	63.2	10,174	13,578	7,809	2,908	34,469	7.8	69,787	9,100	49,222	128,109	29.0	441,876	100
89	293,789	413	294,202	63.7	10,225	13,698	8,839	2,948	35,710	7.7	71,614	9,402	50,706	131,722	28.5	461,634	100
90	313,527	421	313,948	64.8	10,195	13,713	9,259	3,098	36,265	7.5	73,471	9,468	51,194	134,133	27.7	484,346	100
91	330,573	423	330,996	65.5	10,220	13,742	9,884	3,238	37,084	7.3	74,890	9,597	52,399	136,886	27.1	504,966	100
92	340,387	422	340,809	65.7	10,247	13,744	10,806	3,346	38,143	7.4	76,686	9,582	53,649	139,917	27.0	518,869	100
93	355,957	449	356,406	65.9	10,386	13,741	11,231	3,484	38,842	7.2	80,896	10,109	54,886	145,891	27.0	541,139	100
94	366,845	443	367,278	65.8	10,481	13,640	11,887	3,573	39,581	7.1	85,037	10,474	55,937	151,448	27.1	558,307	100

Notes: 1. For natural science only and figures are as of April 1 in each year.

2. Classification of public corporations (a) and (b) is the same as in Appendix 5.

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

9. R&D expenditures and number of researchers of companies, etc. by industry in Japan

(1) R&D expenditures per researcher

(in FY 1993)

Industry	Number of companies, etc. conducting research activities	Research expenditures performed	Number of researchers	Research expenditures per researcher
		million yen	persons	million yen
All industries	12,228	9,053,608	356,406	25.40
Agriculture, forestry and fisheries	20	8,322	284	29.30
Mining	27	27,974	883	31.68
Construction	487	248,201	9,063	27.39
Manufacturing	11,615	8,454,623	339,912	24.87
Food	1,087	211,403	10,167	20.79
Textiles	445	93,063	5,536	16.81
Pulp and paper products	125	41,788	2,173	19.23
Printing and publishing	39	30,878	1,313	23.52
Chemicals	1,566	1,561,433	58,205	26.83
Petroleum and coal products	82	81,853	2,077	39.41
Plastic products	489	113,667	4,271	26.61
Rubber products	243	124,525	5,372	23.18
Ceramics	619	198,429	8,675	22.87
Iron and steel	109	286,114	6,561	43.61
Non-ferrous metals and products	264	148,404	4,824	30.76
Fabricated metal products	852	120,388	6,239	19.30
General machinery	2,235	661,115	30,800	21.46
Electrical machinery	1,946	3,019,847	134,918	22.38
Transport equipment	417	1,297,072	35,669	36.36
Precision instruments	464	321,477	15,979	20.12
Other manufacturing	633	143,166	7,133	20.07
Transport, communication and public utility	79	314,489	6,264	50.21

Note: The number of companies, etc. conducting research activities is the number of companies, etc. which conducted research activities in FY1993. The number of researchers is as of April 1, 1993.

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

(2) Number of researchers per 10-thousand employees

(1994)

Industry	Number of researchers	Composition ratio in the number of researchers	Number of employees of companies, etc. conducting R&D activities	Number of researchers per 10-thousand employees
	persons	%	persons	persons
All industries	367,278	100.0	6,774,040	542
Agriculture, forestry and fisheries	329	0.1	16,084	205
Mining	821	0.2	24,010	342
Construction	8,351	2.3	568,366	147
Manufacturing	351,146	95.6	5,368,666	654
Food	11,309	3.1	412,713	274
Textiles	4,065	1.1	138,493	294
Pulp and paper products	2,289	0.6	86,820	264
Printing and publishing	1,484	0.4	104,434	142
Chemicals	59,240	16.1	599,928	987
Petroleum and coal products	2,134	0.6	47,790	447
Plastic products	5,327	1.5	125,729	424
Rubber products	5,861	1.6	111,948	524
Ceramics	8,330	2.3	202,916	411
Iron and steel	6,319	1.7	230,063	275
Non-ferrous metals and products	5,472	1.5	137,215	399
Fabricated metal products	6,968	1.9	223,181	312
General machinery	31,510	8.6	585,538	538
Electrical machinery	140,539	38.3	1,274,269	1,103
Transport equipment	35,674	9.7	697,846	511
Precision instruments	17,593	4.8	188,529	933
Other manufacturing	7,032	1.9	201,254	349
Transport, communication and public utility	6,631	1.8	796,914	83

Note: Figures are as of April 1, 1994.

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

10. Changes in ratio of company R&D expenditures to sales figures in Japan

(%)

Fiscal year industry	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
All industries	1.97	1.99	2.31	2.57	2.59	2.60	2.72	2.78	2.81	2.83	2.76
Agriculture, forestry and fisheries	0.26	0.24	0.24	0.24	0.31	0.38	0.21	0.50	0.25	0.28	0.43
Mining	0.59	0.63	1.03	1.16	1.01	1.27	0.94	1.13	1.41	1.38	1.17
Construction	0.53	0.47	0.49	0.55	0.51	0.49	0.52	0.54	0.46	0.55	0.54
Manufacturing	2.31	2.34	2.69	3.03	3.14	3.15	3.29	3.36	3.47	3.52	3.47
Food	0.70	0.60	0.77	0.85	0.99	0.89	1.07	0.98	0.95	0.93	1.01
Textiles	0.90	1.16	1.18	1.23	1.42	1.50	1.71	1.76	1.81	2.31	1.98
Pulp and paper products	0.63	0.66	0.71	0.80	0.77	0.87	0.79	0.88	0.87	0.85	0.88
Printing and publishing	0.43	0.61	0.68	0.64	0.80	0.63	0.71	0.88	0.91	0.87	0.81
Chemicals	3.34	3.46	3.79	4.31	4.53	4.63	4.84	4.89	5.24	5.39	5.45
Industrial chemicals and chemical fibers	2.32	2.47	2.80	3.56	3.76	3.92	4.09	4.01	4.19	4.19	4.34
Oils and paints	2.83	3.09	3.14	3.42	3.85	3.74	3.93	3.90	4.20	4.38	4.48
Drugs and medicines	6.59	6.49	7.04	6.89	6.96	6.94	7.50	8.02	8.66	8.70	8.23
Other chemicals	3.40	3.76	3.61	3.87	4.00	4.11	4.11	4.06	4.29	4.56	4.69
Petroleum and coal products	0.26	0.27	0.38	0.62	0.64	0.83	0.72	0.64	0.66	0.67	0.65
Plastic products	—	1.94	1.75	2.09	2.16	2.21	2.73	2.37	2.08	2.35	2.17
Rubber products	2.40	2.62	2.86	2.92	3.25	3.19	3.25	3.20	3.18	3.46	3.39
Ceramics	1.82	1.96	2.61	2.87	2.82	2.73	2.75	2.60	3.00	2.69	2.46
Iron and steel	1.60	1.52	1.94	2.54	2.40	2.13	2.21	2.33	2.84	2.58	2.72
Non-ferrous metals and products	1.49	1.64	1.92	2.11	1.90	2.00	1.91	1.80	2.17	2.23	2.41
Fabricated metal products	1.31	1.46	1.59	1.61	1.50	1.48	1.36	1.60	1.60	1.52	1.48
General machinery	2.57	2.59	2.74	2.77	2.99	2.60	2.83	2.99	3.14	3.10	3.34
Electrical machinery	4.70	4.55	5.10	5.50	5.61	5.53	5.89	5.86	6.31	6.17	6.04
Electrical machinery, equipment and supplies	4.40	4.45	4.82	5.23	5.26	5.25	5.47	5.36	5.66	5.66	5.81
Communication and electronics equipment	4.85	4.60	5.25	5.63	5.78	5.66	6.10	6.12	6.63	6.42	6.16
Transport equipment	2.66	2.76	2.90	3.21	3.22	3.31	3.40	3.65	3.32	3.45	3.15
Motor vehicles	2.89	2.90	2.96	3.20	3.17	3.31	3.48	3.73	3.33	3.54	3.19
Other transport equipment	1.86	2.20	2.61	3.28	3.45	3.31	2.93	3.20	3.24	2.97	2.96
Precision instruments	4.02	4.08	4.49	4.59	4.91	4.85	5.16	5.94	4.85	5.79	5.66
Other manufacturing	1.30	0.92	0.97	1.07	1.12	1.14	1.19	1.21	1.21	1.38	1.51
Transport, communication and public utility	0.39	0.84	0.98	0.96	0.84	0.95	1.06	1.07	0.85	0.87	0.88

Notes: 1. Figures are the ratio of R&D expenditures spent by themselves to sales amount.
2. Figures are for companies only, excluding public corporations.

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

11. Changes in Japan's technology trade amounts

(100 million yen)

Classification / Year	Export (A)	Import (B)	Ratio A/B
1971	213	1,638	0.13
72	212	1,655	0.13
73	231	1,850	0.12
74	324	2,153	0.15
75	421	2,069	0.20
76	519	2,373	0.22
77	548	2,647	0.21
78	591	2,460	0.24
79	703	2,791	0.25
80	803	3,011	0.27
81	1,063	3,775	0.28
82	1,392	4,369	0.32
83	1,351	4,707	0.29
84	1,651	5,401	0.31
85	1,724	5,631	0.31
86	1,527	5,454	0.28
87	1,870	5,515	0.34
88	2,099	6,429	0.33
89	2,782	7,347	0.38
90	3,590	8,744	0.41
91	3,861	8,159	0.47
92	3,867	9,105	0.42
93	4,311	7,981	0.54

Note: Figures are values in each calendar year.
Source: The Bank of Japan, "Balance of Payments Monthly".

12. Changes in technology trade amounts by industry in Japan

(1) Technology export amounts

Fiscal year Industry	1984	1985	1986	1987	1988	1989
All industries	277,512	234,220	224,078	215,575	246,255	329,348
Manufacturing	231,860	205,588	193,483	200,772	228,557	316,241
Food	6,820	6,139	4,945	4,982	5,787	8,337
Textiles	3,855	4,001	4,633	4,385	4,361	4,648
Chemicals	37,502	38,233	38,235	39,295	48,100	53,616
Ceramics	11,238	9,450	5,468	6,194	5,723	9,025
Iron and steel	32,395	26,195	21,540	9,993	10,798	21,572
Non-ferrous metals and products	1,924	1,947	3,586	2,614	2,011	7,054
Fabricated metal products	1,275	2,394	1,525	1,291	1,147	2,004
General machinery	11,396	11,714	6,806	8,741	10,818	13,210
Electrical machinery	47,150	59,460	53,001	61,126	68,795	86,708
Transport equipment	39,784	32,386	43,840	49,213	58,404	87,126
Precision instruments	1,802	1,725	1,850	2,921	4,611	12,556
Other manufacturing	36,721	11,946	8,055	10,017	8,002	10,385
Construction	44,638	26,530	20,835	12,801	16,797	12,448
Other non-manufacturing	1,014	2,101	9,759	2,002	901	659

(2) Technology import amounts

Fiscal year Industry	1984	1985	1986	1987	1988	1989
All industries	281,447	293,173	260,577	283,245	312,195	329,925
Manufacturing	276,895	288,628	258,393	280,996	309,490	326,901
Food	9,480	10,422	10,793	9,785	13,397	8,471
Textiles	9,447	3,287	3,246	3,683	4,910	4,847
Chemicals	40,765	37,387	40,583	40,554	50,335	56,866
Ceramics	8,378	32,404	6,589	6,554	3,735	4,092
Iron and steel	5,562	4,698	5,780	8,013	7,867	4,776
Non-ferrous metals and products	5,100	5,078	4,158	10,719	14,619	10,702
Fabricated metal products	3,606	3,922	3,091	2,901	2,166	2,279
General machinery	23,905	24,483	25,413	21,298	22,592	32,986
Electrical machinery	94,907	84,197	91,264	109,455	113,778	120,553
Transport equipment	55,243	59,704	49,045	48,751	51,955	54,912
Precision instruments	4,386	5,059	4,154	6,677	7,265	8,302
Other manufacturing	16,116	17,987	14,275	12,606	16,871	18,115
Construction	2,294	3,476	1,755	934	966	2,043
Other non-manufacturing	2,257	1,070	428	1,315	1,739	981

Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

(million yen)

1990	1991	1992	1993	Composition ratio (%)	Ratio to the previous year	Amounts per one contract (million yen)	Percentage of receipts to R&D expenditures (%)
339,352	370,552	377,691	400,362	100.0	1.06	48.0	6.2
320,707	348,020	372,778	394,144	98.4	1.06	48.1	6.2
8,044	9,103	7,596	5,432	1.4	0.72	32.5	6.5
3,944	3,618	3,450	4,854	1.2	1.41	21.3	8.7
58,173	58,802	57,057	59,348	14.8	1.04	41.9	5.2
11,860	11,583	16,155	9,808	2.4	0.61	34.2	6.6
9,424	10,527	8,802	13,294	3.3	1.51	28.8	4.9
7,239	4,185	3,318	3,640	0.9	1.10	12.3	3.1
2,418	2,802	3,173	4,698	1.2	1.48	18.9	8.4
14,364	15,113	21,847	18,425	4.6	0.84	18.7	4.9
97,017	105,758	106,728	127,377	31.8	1.19	61.6	5.3
92,014	102,140	126,519	127,670	31.9	1.01	102.5	10.6
4,322	12,094	5,058	4,036	1.0	0.80	24.3	1.8
11,888	12,295	13,075	15,563	3.9	1.19	24.9	4.7
16,949	21,334	3,159	4,360	1.1	1.38	56.6	6.8
1,696	1,199	1,754	1,859	0.5	1.06	28.2	4.3

(million yen)

1990	1991	1992	1993	Composition ratio (%)	Ratio to the previous year	Amounts per one contract (million yen)	Percentage of payment to R&D expenditures (%)
371,907	394,661	413,908	362,974	100.0	0.88	47.0	5.5
368,284	393,163	410,677	369,601	99.1	0.88	47.6	5.6
8,629	8,826	7,691	8,430	2.3	1.10	90.6	13.5
4,722	5,855	6,719	6,188	1.7	0.92	58.9	12.4
54,043	67,403	70,672	61,368	16.9	0.87	65.8	5.5
3,909	4,744	7,852	3,828	1.1	0.49	21.4	2.7
6,489	5,956	3,467	3,403	0.9	0.98	13.1	1.3
13,890	10,378	6,314	3,620	1.0	0.57	17.8	3.0
2,364	2,399	1,738	1,505	0.4	0.87	12.0	4.1
30,533	33,208	27,907	25,554	7.0	0.92	26.1	6.9
159,869	161,259	178,879	159,159	43.8	0.89	65.0	6.1
52,314	56,540	53,374	40,392	11.1	0.76	34.6	3.6
11,389	12,743	22,051	22,747	6.3	1.03	52.8	9.0
20,133	23,852	24,013	23,409	6.4	0.97	37.2	7.3
1,794	687	1,190	724	0.2	0.61	6.5	0.6
1,830	811	2,039	2,650	0.7	1.30	42.7	6.7

13. Changes in technology trade amounts of Japan by region and country

(1) Technology export amounts

(100 million yen)

Fiscal year Region and country	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	Composition ratio (%)	Ratio to the previous year
Asia (excluding West Asia)	1,125.16	875.23	864.81	864.35	1,014.12	1,288.62	1,533.17	1,705.46	1,663.67	1,864.16	46.56	1.12
West Asia	307.83	141.13	104.85	15.88	22.77	23.60	19.59	36.69	15.81	17.80	0.44	1.13
North America	719.15	587.40	622.88	725.02	769.76	1,151.36	1,081.20	1,171.47	1,260.79	1,287.61	32.16	1.02
South America	36.54	87.40	51.61	44.60	44.43	45.80	29.49	30.65	42.69	37.50	0.94	0.88
Europe	407.07	454.61	435.98	402.61	492.62	650.67	614.66	670.91	643.91	677.23	16.92	1.05
Africa and Oceania	179.36	196.44	160.65	103.29	118.85	133.43	115.40	90.35	150.04	119.32	2.98	0.80
Total	**2,775.12**	**2,342.20**	**2,240.78**	**2,155.75**	**2,462.55**	**3,293.48**	**3,393.52**	**3,705.52**	**3,776.91**	**4,003.62**	**100.00**	**1.06**
Korea	149	182	211	275	306	385	465	465	394	504	12.59	1.28
China (including Taiwan)	531	343	282	217	216	244	225	279	382	370	9.24	0.97
(Taiwan)	100	79	85	123	132	163	157	201	217	207	5.17	0.95
Indonesia	136	94	152	85	103	109	197	217	131	119	2.96	0.91
Thailand	83	62	54	73	99	176	246	216	245	325	8.13	1.33
Singapore	91	61	48	66	121	161	185	259	240	248	6.19	1.03
USA	659	518	577	659	711	1,077	995	1,057	1,119	1,192	29.78	1.07
Brazil	19	33	38	25	25	33	17	19	22	21	0.51	0.92
UK	68	53	76	106	139	200	201	245	248	307	7.66	1.23
Italy	57	51	72	37	48	39	55	44	62	28	0.69	0.44
Former Soviet Union	11	24	5	27	45	89	16	12	2	4	0.10	2.29
Germany	47	113	78	74	107	137	117	133	99	95	2.37	0.96
France	46	48	59	52	44	71	94	111	113	106	2.64	0.93
Australia	41	119	58	42	52	57	46	47	50	54	1.36	1.09

Source: “Report on the Survey of Research and Development” by the Statistics Bureau, Management and Coordination Agency.

(2) Technology import amounts

(100 million yen)

Fiscal year Region and country	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993		
											Composition ratio (%)	Ratio to the previous year
North America	1,939.89	2,102.79	1,745.51	1,792.51	1,981.27	2,107.41	2,578.71	2,751.68	2,938.98	2,590.50	71.37	0.88
Europe	866.98	815.67	851.37	1,034.17	1,136.02	1,181.63	1,127.62	1,186.13	1,187.33	1,023.80	28.21	0.86
Others	7.60	13.27	8.88	5.78	4.65	10.20	12.72	8.79	12.77	15.44	0.43	1.21
Total	**2,814.47**	**2,931.73**	**2,605.77**	**2,832.45**	**3,121.95**	**3,299.25**	**3,719.07**	**3,946.61**	**4,139.08**	**3,629.74**	**100.00**	**0.88**
USA	1,930	2,086	1,738	1,786	1,969	2,095	2,553	2,733	2,922	2,578	71.02	0.88
UK	132	146	130	103	93	108	99	108	166	140	3.87	0.85
Italy	48	15	22	12	23	25	24	58	41	37	1.02	0.90
Netherlands	141	155	156	208	276	211	202	246	224	216	5.95	0.97
Switzerland	160	163	175	174	184	190	153	156	166	158	4.35	0.95
Germany	178	176	207	214	184	243	270	252	234	188	5.17	0.80
France	104	68	73	221	262	255	228	220	209	161	4.44	0.77

Source: “Report on the Survey of Research and Development” by the Statistics Bureau, Management and Coordination Agency.

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14. Japan's technology trade amounts by industry and region (in FY1993)

(million yen)

Item	Export amounts							Import amounts			
	Total	Asia (excluding West Asia)	West Asia	North America	South America	Europe	Others	Total	North America	Europe	Others
All industries	400,362	186,416	1,780	128,761	3,750	67,723	11,932	362,974	259,050	102,380	1,544
Construction	4,360	4,297	—	X	X	61	—	724	249	475	X
Manufacturing	394,144	180,989	1,779	128,175	3,713	67,557	11,930	359,601	256,794	101,305	1,501
Food	5,432	2,388	X	1,641	X	1,260	X	8,430	2,769	5,656	X
Textiles	4,854	4,273	—	80	X	474	X	6,188	846	5,251	X
Pulp and paper products	2,207	957	X	736	X	475	X	381	232	X	—
Printing and publishing	178	126	—	44	—	X	X	547	414	133	—
Chemicals	59,348	15,126	132	26,257	414	16,688	732	61,368	34,005	27,336	26
Petroleum and coal products	237	68	—	19	X	143	X	3,077	1,105	1,972	—
Plastic products	1,843	789	—	419	—	625	X	1,764	1,433	321	X
Rubber products	5,285	2,966	X	1,406	—	331	X	4,114	1,671	2,428	X
Ceramics	9,808	7,083	X	1,603	197	608	204	3,828	2,634	1,192	—
Iron and steel	13,294	5,761	292	1,913	738	1,944	2,645	3,403	2,122	1,271	X
Non-ferrous metals and products	3,640	2,555	—	403	X	316	151	3,620	2,270	1,345	X
Fabricated metal products	4,698	3,601	—	659	—	396	41	1,505	590	907	X
General machinery	18,425	7,814	X	6,860	10	3,608	89	25,554	17,591	7,694	268
Electrical machinery	127,377	81,128	184	27,823	1,206	16,261	776	159,159	129,063	30,059	37
Transport equipment	127,670	43,522	604	53,538	722	22,302	6,981	40,392	28,799	11,307	286
Precision instruments	4,036	699	—	1,971	X	1,327	X	22,747	20,291	1,767	689
Other manufacturing	5,813	2,132	X	2,802	X	794	59	13,526	10,960	2,513	X
Others	1,859	1,130	1	585	37	104	2	2,650	2,008	599	43

Note: "—" indicates "none" and "X" shows that values are not expressed because the number of contracts is not more than 4.
Source: "Report on the Survey of Research and Development" by the Statistics Bureau, Management and Coordination Agency.

15. Deflators of R&D expenditures in Japan

Sector / Fiscal year	Natural sciences				Total including social sciences and humanities
	Companies, etc.	Research institutions	Universities and colleges	Total	
1971	55.2	54.2	59.2	55.6	56.1
72	58.9	57.7	64.0	59.3	60.0
73	66.5	65.4	69.8	66.7	67.1
74	76.4	75.4	77.4	76.4	76.2
75	78.8	77.7	79.2	78.7	78.4
76	82.3	81.2	81.8	82.1	81.6
77	83.5	82.6	83.1	83.4	82.9
78	83.8	83.1	84.2	83.7	83.6
79	89.7	88.7	87.8	89.3	88.7
80	94.6	93.7	89.9	94.0	92.7
81	96.0	95.2	91.3	95.3	94.1
82	97.4	96.5	92.8	96.7	95.6
83	97.0	96.2	92.8	96.4	95.5
84	98.1	97.4	94.0	97.5	96.7
85	97.1	96.5	93.8	96.6	96.0
86	93.9	93.5	93.0	93.7	93.6
87	94.1	93.7	93.8	94.0	93.9
88	95.5	95.1	96.0	95.5	95.5
89	98.4	98.1	98.5	98.3	98.4
90	100.0	100.0	100.0	100.0	100.0
91	100.6	100.8	100.8	100.6	100.7
92	100.3	100.6	100.7	100.4	100.4
93	99.1	99.6	100.1	99.3	99.5

Source: The Statistics Bureau, Management and Coordination Agency.

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